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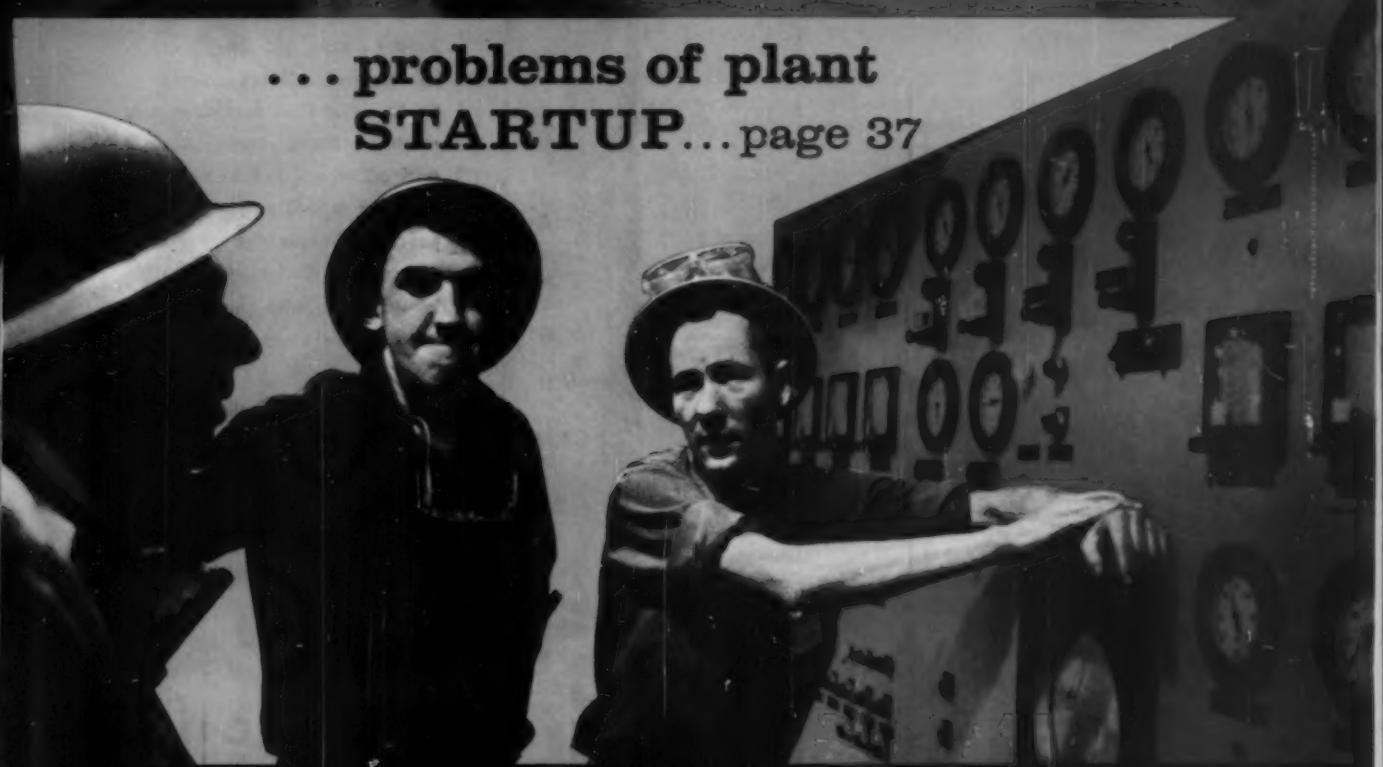
CHEMICAL ENGINEERING PROGRESS

AUGUST 1959



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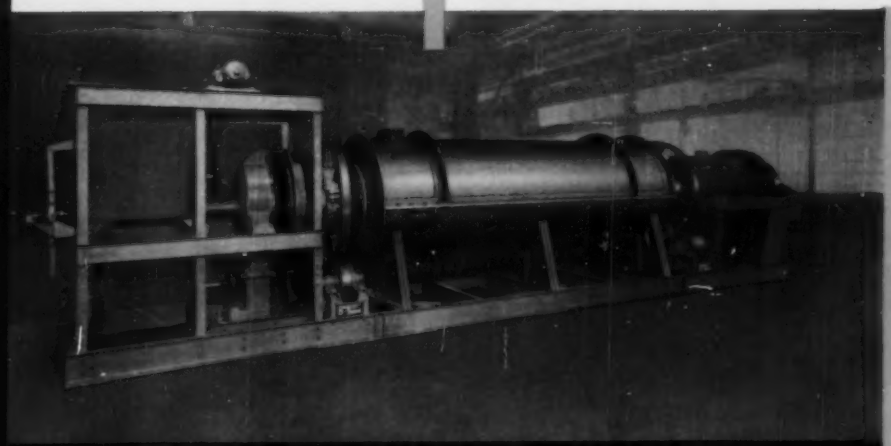

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AUGUST 1959 Volume 55, No. 8

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Cover by *Paul Arlt*. Halftone photos of Dupont's Tecumseh, Kansas, cellophane plant startup courtesy of Dupont's Better Living.

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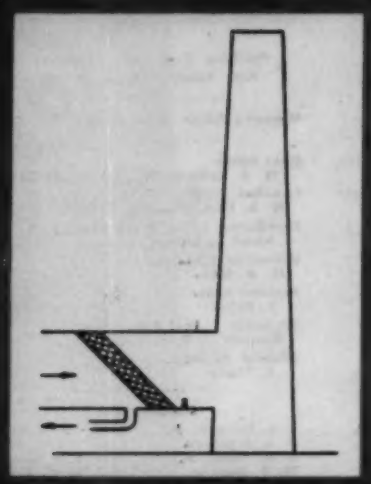

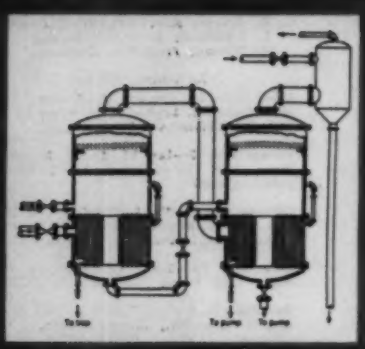

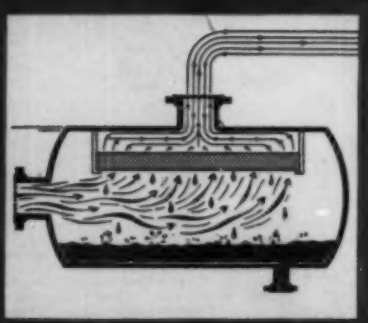

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Industrial cooling towers, Simplified control systems engineering, among new book subjects

THE INDUSTRIAL COOLING TOWER, K. K. McKelvey and M. Brooke, D. Van Nostrand Co., Princeton, N. J., (1959), 429 p., $15.75.

Reviewed by A. L. Fuller, Senior Engineer in charge of Cooling Tower Research and Development, Fluor Corporation, Ltd., Whittier, California.

Here is a book which should be welcomed by designers and users of cooling towers the world over. The book brings together, in one volume, a considerable amount of important and useful data on evaporative water cooling and the associated heat and mass transfer equipment in which the process is carried out. It is divided into sixteen chapters covering psychrometry, fundamentals, heat transfer, natural draft towers, tower performance, packing arrangements, types of cooling equipment, mist elimination, recirculation, water treatment, structural design, auxiliary equipment, economics, tower selection, tower construction, and tower testing. Quite complete.

The authors have undertaken a project of considerable scope, and of collecting and assembling data from many countries into a homogeneous reference on water cooling technology. The book includes engineering data principally from U. S. A., Canada, England, Ireland, The Netherlands, Germany, France, Sweden, Russia, Egypt, and India.

It was noted that the definitions in the "List of Symbols," which are in themselves somewhat sketchy, do not include a set of customarily used units. The units are given in the text. Although this situation makes the book unhandy at times, it is somewhat understandable when the international coverage and scope of the book are considered.

Of considerable interest to U. S. engineers is the thorough treatment given hyperbolic cooling towers. Mr. K. K. McKelvey, who is a chartered civil and structural engineer in London with experience in reinforced concrete engineering (among other things), has authoritatively described the performance and structural design considerations, the construction, the operation and the maintenance of these huge structures.

Mr. Maxey Brooke is supervisory chemist for Phillips Petroleum Company in Sweeny, Texas, and chairman of the committee on cooling water in the "National Association of Corrosion Engineers." Brooke has written many papers on water and has contributed a lot of very practical "know-how" information on the operation, maintenance, and water control problems which confront tower operators throughout the world.

This book is recommended as being highly useful to engineers and operators of cooling tower equipment. Its aim to give broad technical and international grounding in evaporative water cooling has been accomplished.

A SIMPLIFIED TECHNIQUE OF CONTROL SYSTEM ENGINEERING, G. K. Tucker and D. M. Wills, Minneapolis Honeywell Regulator Co., (1958), 303 p.

Reviewed by Theodore J. Williams, Monsanto Chemical Company.

Messrs. Tucker and Wills have authored a truly remarkable little textbook in their "Simplified Technique of Control System Engineering". While being elementary to the highest degree and in addition confining itself almost completely to algebra in its mathematical treatment, it still manages to convey an amazing amount of information about the complex subject of automatic control. It accomplishes this by means of a very large number of very clear figures (136) and illustrative tables (19) in its 303 pages. In addition, the writing style is quite clear and easy to read, while the step-by-step method of presenting the details of problem analysis and of problem solution is extremely easy to follow.

This book is particularly recommended for the technician or the engineer just beginning a study of the subject of automatic control. However, because of its elementary nature, this text confines itself to the Bodé method of data presentation, to linear systems, and to the manipulation of experimental data and standard control elements. Thus, the reader will find that he must go very soon to much more advanced texts for further detailed knowledge of his subject. At the same time, I am sure he will find that his understanding of these latter texts will be much improved by the insight which Tucker and Wills' book has given him into control system behavior. Indeed, I would guess that even the most experienced control engineer would find his appreciation of his subject improved by a reading of this book and an exposure to these authors' viewpoint on the presentation of this material.

This text is too elementary to be recommended as a college text, but its use as subsidiary reading material to help illustrate some of the more difficult parts of the standard texts would well justify its inclusion in all school libraries. As mentioned above, it is highly recommended for the chemical engineer beginning a study of process control on his own. It would also be very valuable for the instrument engineer or instrument technician adjusting control systems,

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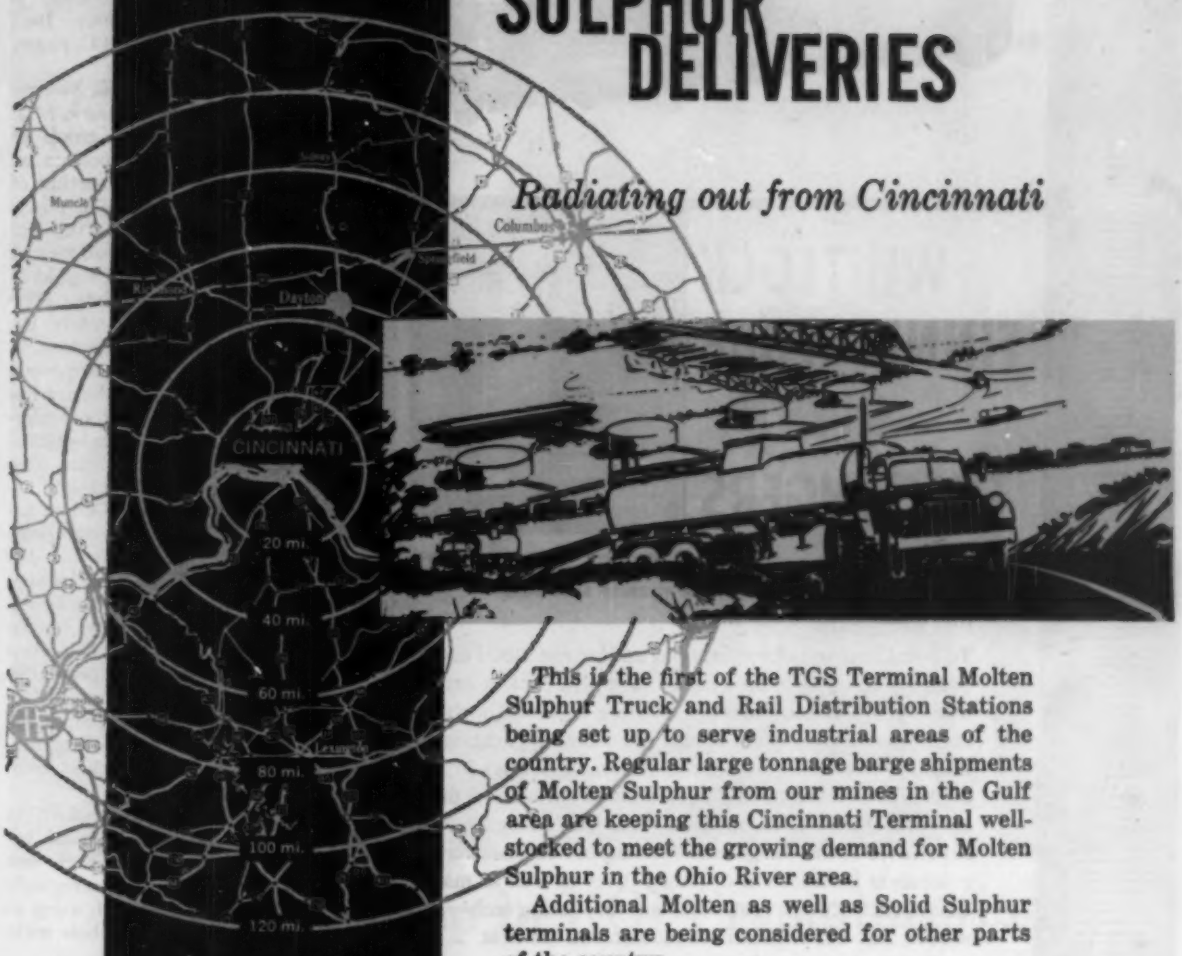

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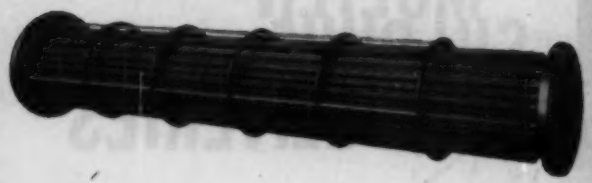

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marginal notes

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since it contains a large number of "rules of thumb" and step-by-step analysis procedures which would be very valuable in this work.

THE STRUCTURE OF ELECTROLYTIC SOLUTIONS, edited by Walter J. Hamer, John Wiley & Sons, Inc., New York, N. Y., (1959), 441 pages, $18.50.

Reviewed by C. L. Mantell, Newark College of Engineering, Newark, N. J.

This book represents a group of papers presented at a symposium on electrolytic solutions at a meeting of The Electrochemical Society in Washington, D. C., 1957, on the 70th Anniversary of the contributions of Arrhenius, van't Huff, and Ostwald to our knowledge of electrolytes. The papers cover activity and osmotic coefficients; incomplete dissociation in aqueous salt solutions; Raman spectral investigations of ionic equilibria; hydrogen bond structure, proton hydration, and proton transfer; ionic vibration potentials; electrostatic free energy of concentrated electrolyte solutions; heats of dilution of dilute solutions; diffusion and activity coefficients; Soret coefficients; thermal diffusion; the emf method of determination of ionization constants; conductance and pH measurements; ionization equilibria; ionic mobility; electrophoresis and conductivity; properties of rare earth salts in electrolytic solutions; thermodynamic properties; aquo-ions and ion pairs; melting mechanisms of ionic crystals; and complex ions in molten salts.

This is a volume for scholars, in that there has been no editorial coordination of the papers, each one standing alone, and, discouragingly from the student's viewpoint, using its own nomenclature and symbols without standardization.

The chapters are individual contributions to a complex historical subject and contain opinions on a wide variety of subjects, some of which may be highly controversial. Typical of a summing up is this statement on page 113:

> "After thirty years no one has yet succeeded in using, or in modifying, the Debye-Hückel theory in a way which is able to give an exact account of activity coefficients, or of heats of dilution, in real solutions without employing parameters which not only are empirical but also take on

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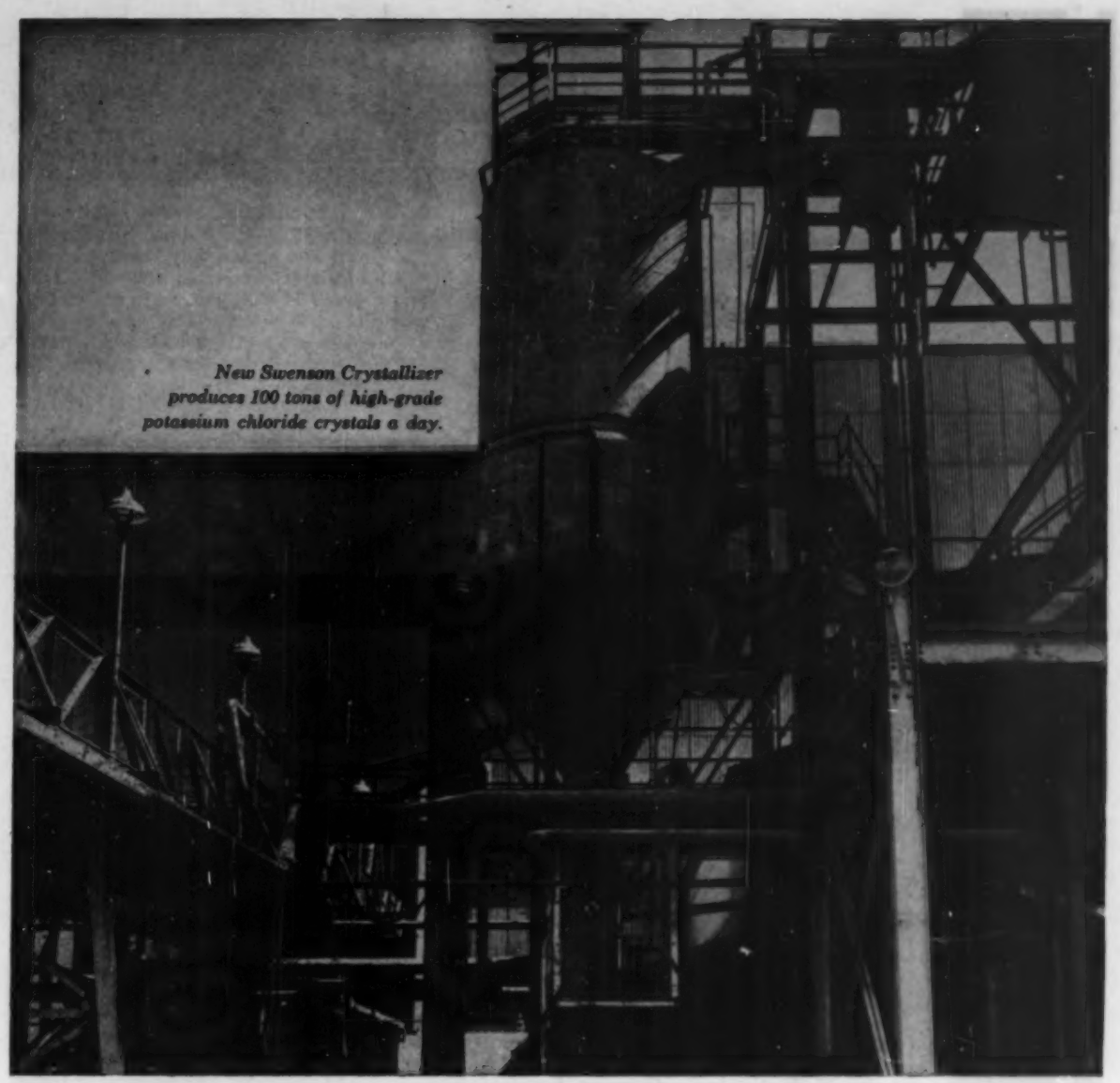

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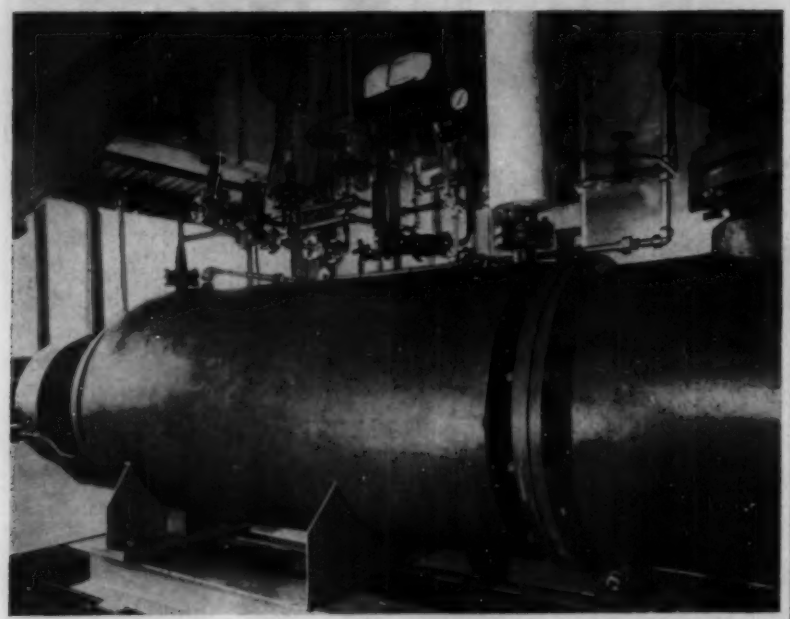

20 square foot Reverse Taper AJUST-O-FILM® Processing Unit at Pfizer's Groton plant

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95% of feed distilled over as product and separated from thin, dark bottoms in exclusive centrifugally-wiped, thin-film, short time continuous process.

In processing heat-liable vitamins, this large drug company uses a Kontro Reverse Taper AJUST-O-FILM with the exclusive blade-clearance adjustment feature for an extremely difficult intermediate step. This involves the nearly complete distillation (95%) of the feed from the thin, dark, undesirable bottoms resembling thin automobile lubricating oil in viscosity. The Reverse Taper controls throughput, permitting the high degree of distillation. Pfizer has found such high percentage, single pass, short time separation virtually impossible except with AJUST-O-FILMs. The high speed close fitting rotor blades continuously produce superior thermal efficiency at 1 mm. vacuum on this heat-sensitive material.

Other process industries, including those involving high viscosity products, have also benefited by using Kontro equipment to put their operations on a continuous thin-film basis. Perhaps you, too, have a specific problem where AJUST-O-FILMs can be profitably employed. Write for complete information on standard units, use of the pilot plant, or rental facilities.

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marginal notes

from page 8

numerical values which are often markedly peculiar."

While all the topics are intriguing to the electrochemical engineer, he will find their utility not applicable to the concentrated solutions from which he manufactures many of our basic chemicals. The volume adds measurably to the basic understanding of the electrically conductive solutions he so often employs.

CHEMICAL PUBLICATIONS: THEIR NATURE AND USE, M. G. Mellon, McGraw-Hill Company, Inc., New York, N.Y. Third edition (1958) 327p. $7.00.

An introduction to the literature of chemistry. Primary literature sources (periodicals, institutional publications, patents), and secondary sources (bibliographies, reference works, monographs, guides) are analyzed.

INFORMATION AND COMMUNICATION PRACTICE IN INDUSTRY, Edited by T. E. R. Singer, Reinhold Publishing Corp., New York, N.Y. (1958), 304p. $8.75.

Considers technical writing, editing, and illustrating; classification; information services; operations research; patent collections; training the literature scientist; translating; indexing and abstracting.

TECHNOLOGY OF COLUMBIUM (NIOBIUM), Edited by B. W. Gonser and E. M. Sherwood, John Wiley & Sons, Inc., New York, N.Y. (1958) 120p. $7.00.

A summary of the present status of knowledge concerning columbium (niobium). Economic and supply aspects, properties, extractive and physical metallurgy, analytical problems, and various specialized aspects are studied in seventeen papers which are included in the book.

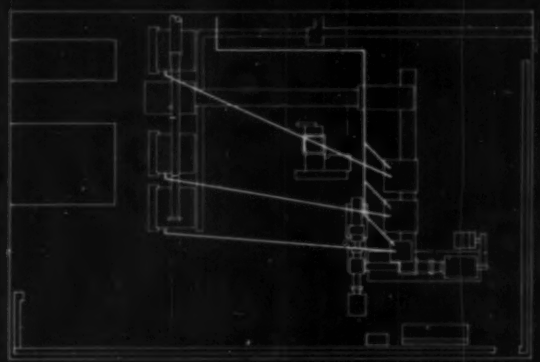
Polimeros S. A., vinyl acetate polymers manufacturers in Mexico City, has been purchased by National Starch & Chemical. Additional equipment will be installed in the plant so that a complete line of vinyl acetate polymers and copolymers, as well as adhesives for the packaging, structural and furniture industries can be made. The Mexican company operates as a wholly owned subsidiary of National Starch.

FORD MOTOR COMPANY
installs BAKER PERKINS machinery for continuous production of re-inforced plastic pre-mix

To achieve all the advantages of automatic processing, Ford Motor Company has installed a completely integrated system for the production of re-inforced plastic pre-mix on a continuous basis. A Baker Perkins Ko-Kneader has successfully solved this tough mixing problem and is the key piece of equipment in the system. Because of this remarkable technical accomplishment, it has been possible to achieve a whole new concept in automated pre-mix production. Baker Perkins supplied all the auxiliary equipment for conveying, weighing and feeding the component materials which included resin, sisal, clay, asbestos and calcium carbonate, as well as the equipment for forming and cutting off the pre-mix after discharge from the Ko-Kneader.

The machines of Baker Perkins manufacture in this installation include: four dump hoppers, complete pneumatic conveyor systems, belt transfer conveyor, resin pump and a model K-250-IM Ko-Kneader.

With this new automated system, Ford Motor Company has been able to capitalize on all the advantages of continuous processing and achieve a production rate of 1800-2400 lbs. of high quality pre-mix per hour. You, too, may be able to utilize the many advantages of the Ko-Kneader for continuous processing. Why not write today for complete information.

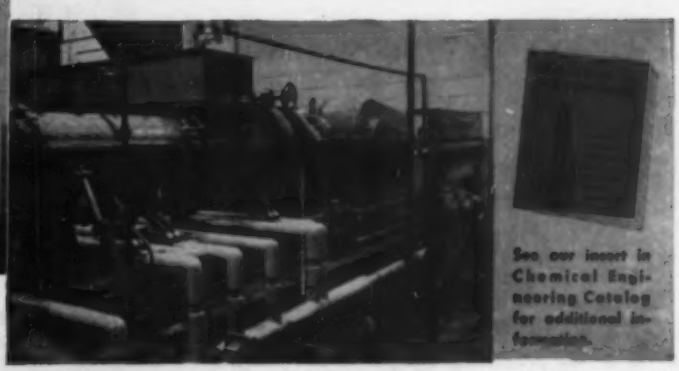


This diagram illustrates the continuous mixing system as installed at Ford Motor Company.

From these B-P dump hoppers the asbestos, clay and calcium carbonate are conveyed by a Baker Perkins pneumatic system to the mixing room. The sisal (second from the left) is moved by a mechanical conveyor.

Close up view of the Baker Perkins model K-250-IM Ko-Kneader. Feed conveyor is at the top, center. Discharge is at extreme lower left.

Overall view of mixing room. The overhead feeders discharge measured amounts of material on conveyor discharging into the Ko-Kneader.



See our insert in Chemical Engineering Catalog for additional information.

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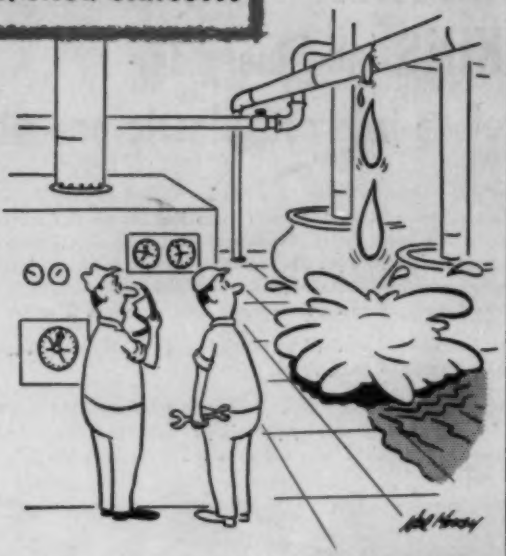
Life in these excited states...



"I can't stand that constant drip-drip-drip!"

Corrosion got the drop on you?

Little drips can mean big losses... repairs, downtime, ruined equipment. You can put an end to 85 to 100% of these problems with Ace chemical-resistant rubber and plastic piping, valves, pumps, tanks and other equipment. American Hard Rubber Company's 108 years of experience is at your service.

All-purpose rigid PVC. Sched. 40, 80 & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". NSF-approved. *Bul. CE-56.*

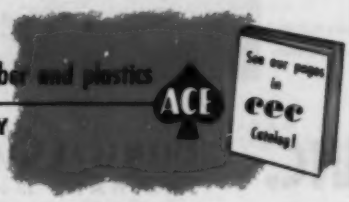
Improved design . . . now 12 gpm. All wetted parts acid-resistant, wear-resistant Ace hard rubber. Finest available. *Bul. CE-55.*

Flexible poly pipe, ideal for water lines, drains, underground pipe or conduit. Sizes ½ to 2", long coils, NSF-approved for drinking water. *Bul. CE-57.*

World's best chemical valves . . . at moderate prices. All-plastic, rubber-lined, or all-hard-rubber. ⅛" pet cocks to 24" gate valves.

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
Ace Road • Butler, New Jersey



For more information, turn to Data Service card, circle No. 71

institutional news

Societies join to encourage students

Over 100 top science students from metropolitan New York senior high schools met with chemical industry leaders at a "Science Day" program held recently at the Chemists Club. Purpose of the all-day conference, under the joint sponsorship of A.I.Ch.E., ACS, AIC, and several other organizations, was to encourage promising students to enter the chemical industry by acquainting them with opportunities in the field.

A battery of outstanding scientists and administrators, and presidents of six major chemical companies was on hand for the panel sessions, which were designed to provide the students with information regarding a career in the field.

The $500 Liebman Memorial Award for the outstanding area science student was presented to Steven Weiner, Newton High School, at a luncheon attended by several leading science students, education officers, representatives from industry and the professional societies and trade associations.

Polyester and alkyd resin is now commercially produced in Denmark with the completion of facilities at the A/S Danske Oliemller O G Saebefabrikker plant in Copenhagen. A special exclusive license agreement between Schenectady Varnish Co., Schenectady, N. Y., and the Danish firm, covers sale in neighboring Scandinavian countries as well.

Lexan polycarbonate resin production at a new GE plant at Mount Vernon, Indiana, is scheduled to start in late 1960. Included in company plans are provisions for expansion.

How Much Does Stuffing Box Leakage Cost You?

Lapp PULSAFEEDER
CONTROLLED-VOLUME CHEMICAL PUMP

Many industrial plants, using small capacity chemical pumps, are confronted with the common problem of stuffing box leakage. Although much is done to accommodate for this pump deficiency, the day-to-day cost of various liquids lost through leakage is usually overlooked.

Normal stuffing box pump leakage is one to three drops per stroke. Thinking in terms of cost per gallon, consider a simplex stuffing box type pump handling phosphoric acid. An average two drops per stroke, 50 strokes per minute leakage represents a yearly operating loss of $1,240. Such costly stuffing box leakage is typical. Yet it can be eliminated instantly by installing a Lapp Pulsafeeder diaphragm pump. The Pulsafeeder has no stuffing box . . . leakage and contamination of liquid being pumped is prevented by a hydraulically balanced diaphragm isolating the liquid from the pump's drive mechanism. Pumping speed is constant; variable flow results from variation in piston-stroke length, controlled manually by hand-wheel, or in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable. Pulsafeeder capacities range from 585 ML per hour up to 24 gpm maximum flow and pressures from minus atmospheric to 6800 psig.

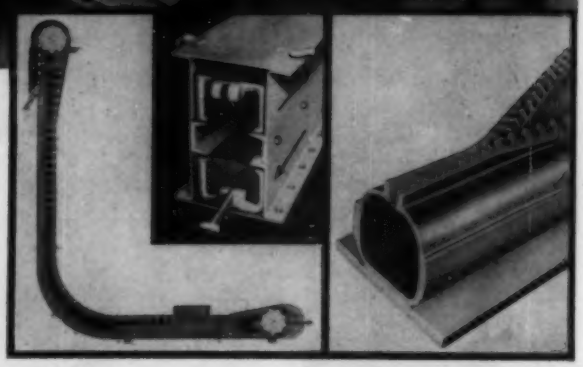
WRITE FOR BULLETIN 440 containing typical applications, flow charts, description and specification of models of various capacities and constructions, also special leakage chart. Lapp Insulator Co., Inc., Process Equipment Division, 3712 Poplar St., Le Roy, New York.

For more information, turn to Data Service card, circle No. 17

STEPHENS-ADAMSON

SA CONTINUOUS WEIGHER PROVIDES EXTREME ACCURACY!

The STEPHENS-ADAMSON Continuous Weigher weighs material continuously while in motion with extreme accuracy. Material entrance and exit points are in line with pivot axis of weigher providing for easy installation within existent processing operations and completely eliminating all discharge terminal errors. The unit handles hot material with equal accuracy. Minimum headroom is required. The weigher can be adapted with control equipment for accurate gravimetric feeding without requiring extensive plant alterations. STEPHENS-ADAMSON engineers will be happy to work with you on automating your processing operations.

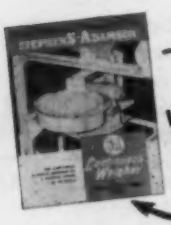


S-A REDLER CONVEYOR

Skeleton flights, linked together and moving through totally enclosed casings, induce the mass movement of powdered, granular or flaky bulk materials in any direction. Gentle conveying action and sealed casings mean maximum protection for materials handled. Redler units combined with Continuous Weigher offer automatic operation. Request Bulletin 358.

S-A ZIPPER CONVEYOR

Literally a moving, material-carrying conduct, the zipper closed belt, conveyor-elevator is capable of transporting bulk materials in any plane, to considerable heights and around obstructions. Bulk materials are conveyed free of breakage, agitation or segregation within the sealed and dustight belt. The zipper combined with Continuous Weigher is ideal for automatic feeding operations. Request Bulletin 349.



WRITE FOR BULLETIN 958

S-A

ENGINEERED BULK HANDLING SYSTEMS

SPIDERVEYOR® PASSENGER CONVEYORS

SPHERICO® BEARINGS & ROD ENDS

ENGINEERING DIVISION

STEPHENS-ADAMSON MFG. CO.

GENERAL OFFICE & MAIN PLANT, 57 RIDGEWAY AVENUE, AURORA, ILLINOIS

PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA • CLARKSDALE, MISSISSIPPI
BELLEVILLE, ONTARIO

For more information, turn to Data Service card, circle No. 19

SCOPE

Eliminate olefins—eliminate L.A. smog

"The positive relationship between automobile exhaust and Los Angeles smog is now accepted by all scientists who have studied the problem," says a recent bulletin from the Air Pollution Foundation. Latest experimental work, according to the Foundation, shows that the constituents of exhaust which take part in this photochemical (sunlight) reaction are certain olefinic hydrocarbons and the nitrogen oxides. Paraffinic hydrocarbons do not participate in the reaction; neither does carbon monoxide.

Main olefins found in exhaust are ethylene (C_2), propylene (C_3), butenes (C_4), pentenes (C_5), and hexenes (C_6). As a class, the C_4's, C_5's, and C_6's have been found to be the most potent formers of eye irritation and ozone. Within these classes, the dienes (butadiene, for example), are said to be the worst offenders as far as eye irritation is concerned.

One particular olefin, trans-2-butene, reacts very rapidly with nitrogen dioxide upon irradiation to form copious quantities of ozone, but little eye irritant. Another, 1-butene, forms large quantities of both ozone and eye irritant. Also, ethylene which, while it reacts much more slowly than the other olefins, is present in auto exhaust in larger quantities than the others, and therefore may still be important in smog formation.

With regard to the aerosol that blurs visibility, less factual information is said to be available. Aerosol formation is believed definitely related to the photochemical oxidation of olefins in the atmosphere, but sulfur dioxide also appears to be involved. A Foundation-sponsored research project at Stanford Research Institute is presently attempting to "unravel these complexities."

According to the Foundation, elimination of atmospheric olefins will probably eliminate smog, from a practical standpoint. Conclusion —"Inasmuch as 95% of the olefins in the air comes from the tailpipes of motor vehicles on our streets and freeways, the point of attack is obvious."

Another possible mode of attack would be to remove oxides of nitrogen from exhaust, since without these ingredients the olefins are said to be harmless. This approach, however, is less clear-cut than elimination of olefins because there are many other sources of atmospheric nitrogen oxides — power plants, furnaces—in fact, all combustion processes.

Synthetic fiber expansion in South and Puerto Rico forecast

"U. S. synthetic fiber producers will spend between $1.1 and $1.3 billion on new facilities by 1975, and 80 percent of this expansion will occur in the South and Puerto Rico," predicts Joseph Airov in a new book "Location of the Synthetic Fiber Industry," published recently by M.I.T. Synthetic fiber capacity, according to Airov, will reach 830 million pounds per year by 1975, with chemical intermediates increasing by 783 million pounds annually.

Spevak heavy water patent issued

Patent #2895803 has finally issued to Jerome S. Spevak after years of legal controversy with AEC over the heavy water production process. (The original patent was issued to AEC in 1943 and covered the basic principle of the "dual-temperature" method). The present patent is understood to cover an improved process which improves the economic feasibility of the older method. Production of heavy water by the process was carried out for the AEC at two plants at Dana, Indiana, and Aiken, South Carolina. Total cost of the two plants is said to have been about $260 million, the capacity of each about 500 tons/year. During World War II production cost is believed to have been from $110 to $150 per pound of heavy water; present selling price is in the neighborhood of $15. The Dana plant has been on "stand-by" since 1957, and is understood to be undergoing conversion for production of classified materials—no details are presently available.

More women to take on role of science teachers?

"Women may well become a major factor in meeting the present critical shortage of competent teachers of mathematics, chemistry, and physics," according to a recent survey conducted by the National Education Association. "Even in engineering," continues the survey report, "some of the major institutions express confidence that women might well be entrusted with some of the basic courses.... Engineering is the field in greatest need of new teachers with substantial backgrounds of academic preparation."

There was, however, according to the survey results, no unanimity of opinion on the point. Of reports from 913 educational institutions, 23% indicated some doubt that the use of women as college and universities can or should be substantially expanded. The preponderance of opinion, 77% nevertheless expressed a readiness to "plumb this source at least somewhat deeper."

Among the fields most frequently mentioned as open to larger numbers of women teachers were the social sciences, English, mathematics, and foreign languages. Then came the physical sciences, which were mentioned even more frequently than education or fine arts, and more than twice as frequently as business and commercial subjects.

The present situation

Mathematics teachers comprise 4.1% of the total full-time college staff; psychology only 2.5%. Yet the number of women receiving the doctor's degree in mathematics is scarcely more than one-sixth as many as receive the degree in psychology. "It seems reasonable to assume," says the NEA survey report, "that women have not been encouraged to anticipate employment as college teachers, at least in pursuing graduate work beyond the master's degree level."

Use of part-time teachers

Can the use of part-time teachers, in various categories, fill the ever increasing gap between the number of college and university enrollments and the number of qualified teachers available? Not entirely, says the NEA. Graduate students, according to the survey, probably constitute a majority of all part-time teachers. However, a good many are drawn from other sources; of these latter, some are in full-time employment in other occupations. "Can the prestige of any profession," asks the NEA, "be built upon an expanding use of part-time persons?" Their conclusion—"Evidence is lacking that the educational progress of students taught by a good many part-time teachers is being appropriately safeguarded."

Washington notes

The National Academy of Sciences has signed an agreement with the U.S.S.R. Academy of Sciences providing for a number of exchange visits between scientists of the two nations during the next two years . . . A new program to provide students of small undergraduate colleges with an opportunity for specialized training in techniques of using radioisotopes has been announced by AEC. The program will start in the fall of 1959, will be available to colleges in the South and Southwest . . . The U. S. Development Loan Fund has approved a $5.6 million loan to the Oriental Chemical Industries Co., Ltd., a private Korean firm, to assist in establishment of a soda-ash plant and related chemical plants at Samchok, Korea . . . *J. L. Gillman, Jr.*

From here and there

A $3.5 million contract for production of the Guardian II pre-packaged rocket engine awarded to Thiokol Chemical by the Navy . . . An Italian manufacturing subsidiary will be formed by Cyanamid International . . . B. F. Goodrich to erect $4.5 million plant in Australia to make Geon vinyl plastics . . . Japan's first synthetic rubber plant, is on stream at Kawasaki. Operating company is Japanese Geon, in which B. F. Goodrich holds a financial interest . . . A $4.5 million chemical plant, primarily a producer of fluorochemicals, will be put up at Decatur, Alabama, by Minnesota Mining & Manufacturing.

Anthracite coal as chemical raw material

Plans are reported* underway for the formation of a $100 million joint venture aimed at the chemical processing of the by-products of anthractie coal mining, long a problem child of the mining industry. The country's largest hard coal producer, Philadelphia & Reading, and General Dynamics, maker of submarines, jet planes, electronic equipment, and industrial gases, and an active participant in nuclear development, are said to project organization of a joint subsidiary, Dynamics Reading Chemicals, which would build and run the chemical processing plants.

A shot in the arm is seen possible for the coal industry, depressed in recent years by stiff competition from oil and natural gas. The key is the economics of the processing steps. At present, coking operations yield gases and other volatile materials which are processed into some 300 different chemicals. Fertilizers, plastics, explosives, and synthetic fibers are only a few of the synthetic products which add up to an estimated sales volume of $270 million.

Tentative plans for the new subsidiary are reported to envisage three major divisions. The first, a large power plant, would burn wastes to make electricity and steam at a cost which is calculated to be below that of the Tennessee Authority. Second division would be a "participation" unit for production of basic chemicals. Finally, an electric furnace unit will be erected, in which limestone and anthracite would be used to produce carbide acetylene and, in an associated reaction with hydrogen chloride, to produce vinyl chloride, raw material for vinyl plastics.

If the recovery processes come up to expectations, Dynamics Reading may be able to offer a wide range of coal chemicals on the market at costs no greater than those of the same products produced from oil or natural gas. However, it should be remembered that other companies, Union Carbide in particular, have invested many millions of dollars in similar projects without the achievement of competitive production costs.

**Information from a Chemical Industry Research Study by Smith, Barney & Co., N. Y. brokerage firm.*

Engineering education exchange expanding

95 U. S. engineering and science students will depart for Europe for temporary employment under the program of the International Association for the Exchange of Students for Technical Experience (IAESTE), whose secretariat is now at Engineers Joint Council. In exchange, 65 European students, from 12 countries, will arrive here for employment in the U. S.

Major gas strike in Southern Italy

Newly discovered natural gas fields near Matera in Southern Italy are expected to be in production soon at a rate of about 2 million cubic feet of gas a day. Exploiting company will be the ENI (Ente Nazionale Idrocarburi).

Ordnance works on auction block

The Maumelle Ordance Works, near Little Rock, Arkansas, built in 1941 and 1942 at a cost of some $14 million, will be offered for public sale on September 29 of this year; the plant during World War II turned out large quantities of picric acid and ammonium picrate for the Army.

Canada to build large atomic power station

At a cost estimated at about $60 million, Atomic Energy of Canada will design and erect a 200,000 electrical kilowatt nuclear power plant using a natural uranium-heavy water system. Site has not yet been fixed, completion is scheduled for late 1964 or early 1965.

Chemical engineers starting salaries up

A "hike" of two percent in the average starting salary for chemical engineering majors graduated in June of this year was reported by Lehigh University. This year's figure was an average of $486 compared to $477 in 1958.

FEinc Rotary Vacuum String Discharge Filters at The Hubinger Company, Keokuk, Iowa.

FOR THE HUBINGER COMPANY . . .

STRING DISCHARGE FILTERS *solved the problem*

These FEinc rotary vacuum filters were recently custom built to specifications for The Hubinger Company, Keokuk, Iowa. The job they're doing is a tough one . . . filtering gluten derived from the wet milling of corn.

The string discharge design was selected as the only workable method for cleanly removing the thin, high-protein gluten cake which causes scraper filters to bog down. Each unit has over 500 square feet of filter area.

LOW MOISTURE CAKE CONTENT

Operating continuously, these string discharge filters eliminate blow-back and produce a cake of low moisture content. Stainless steel construction helps maintain product purity according to standards established in over 75 years of starch production.

The FEinc filters in this installation are examples of how custom-made units provide solutions to many difficult continuous filtration problems in the chemical processing industry.

For help with your problem, see our insert in Chemical Engineering Catalog or write today, Dept. CEPF-859, for free bulletins and technical advice. Simply state your basic requirements.

For a Bigger Yield **FE INC.**

FILTRATION ENGINEERS
AMERICAN MACHINE AND METALS, INC
EAST MOLINE ILLINOIS

STRING HORIZONTAL SCRAPER

CUSTOM DESIGNED CONTINUOUS FILTRATION

For more information, turn to Data Service card, circle No. 82

For more information, circle No. 110

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U.S.I. CHEMICAL NEWS

August ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1959

U.S.I. Names New Manager For Alcohol, Solvent Sales

Thomas R. Drinkwater has been named Manager of Industrial Alcohol and Solvents Sales for U.S.I., largest marketer of ethyl alcohol in the U.S. In his new position, Mr. Drinkwater succeeds Warren E. Johnson who has just been appointed Director of Chemical Sales.

T. R. Drinkwater

Mr. Drinkwater worked out of the company's Chicago Sales office until 1957 when he was made Assistant to the Manager of Alcohol and Chemical Sales, the position he was holding at the time of this new appointment.

Alcohol Aerosol Formulas Proposed for Gibberellin

Because the remarkable plant growth stimulant, gibberellin, has proven effective in dosages as low as 5-10 micrograms, aerosol dispensing has been suggested as a highly accurate, convenient and economical means of applying the material. Using a meter-type valve designed to release about 100 milligrams of formulation containing about 5 micrograms of stimulant, one 3-ounce aerosol container (2 ounce practical fill) could give more than 500 applications.

Gibberellin is said to lose its effectiveness gradually in water solutions, and consequently all formulas which have been suggested for the material have been nonaqueous. The following composition for packaging in glass has been proposed:

Gibberellin	0.00625 wt. %
Surfactant	0.200
S.D. Alcohol #40, anhyd.—q.s.	50.00
Propellant	50.00

This composition is among those recommended for packaging in lacquer-lined metal:

Gibberellin	0.00625 wt. %
Surfactant	0.2
S.D. Alcohol #40, anhyd.—q.s.	20.0
Propellant	80.0

Polyethylene Used for New Box-Type Mixer-Settler

The recently-reported development of a polyethylene, box-type, mixer-settler extractor — one of the first complex pieces of process equipment made almost entirely of polyethylene — points the way to still greater utilization of this tough, corrosion-resistant plastic as a material of construction for the Chemical Process Industries.

This piece of equipment was designed to handle corrosive chemicals used in the separation of materials by liquid-liquid extraction. It is a horizontal contactor in the form of a rectangular box about nine inches high. The box is divided into sections, each of which handles a stage in the extraction process. Each section contains a mixing chamber suspended in an antechamber, and a settling

MORE

U.S.I. Completes Million-Gallon Concrete Storage Tank for Phosphatic Fertilizer Solutions

One of Largest Ever Built for Phosphoric Acid Storage, Tank Holds 1½-Month's Plant Production, Is Designed To Increase Supply to Fertilizer Formulators

An innovation in phosphoric acid storage tanks — a reinforced concrete structure with a capacity of over a million gallons of phosphatic fertilizer solution — has just been completed at Tuscola, Illinois, site of U.S.I.'s wet-process phosphoric acid plant. This 100 ton-per-day plant serves fertilizer formulators in a 12-state area, and operates under the usual seasonal demand conditions of the agricultural chemicals field.

When the outsized storage tank goes into service this month, it will help smooth out the supply-demand curve both for U.S.I. and for the formulators served by the company. The tank will increase the plant's storage capacity by 1½ months' production, insuring formulators of a steady supply of raw material for their late winter and early spring compounding season.

The tank, built by the Preload Company, Inc. of New York, is one of the largest ever constructed for phosphoric acid storage, measuring 100 feet in diameter by 21½ feet high. It is made of reinforced concrete which was built up in place on a wire mesh form and pre-stressed in the construction. This is an innovation in tank design, since most phosphoric acid storage is in lined steel tanks.

Phosphoric as Fertilizer Material

While wet-process phosphoric acid has been an intermediate in triple superphosphate production for many years, its use as a raw material for mixed fertilizer generally dates back only to 1957. That use is growing rapidly for a number of reasons: It is the only commercial source of P_2O_5 in liquid form, which eliminates dusting and the problems of handling solids. It is by far the most highly acid

MORE

Sodium Borohydride Is Key To New Vinyl Foam Process

A new process for making vinyl foams has been developed, using sodium borohydride as the blowing agent. It is claimed that the new method yields a product with fine, uniform cell structure, low density and low compression set — using simple equipment and techniques. In addition, the process is said to permit the molding of small, intricate shapes unobtainable previously with vinyl foams.

Sodium borohydride, reacted with water in a mildly acid medium, gives sodium borate and hydrogen gas. The gas does the blowing and foaming. Control of the foam depends on the treatment of the borohydride before it is incorporated into the plastisol, and on the choice of activator promoting decomposition.

Heat and plasticizer viscosity are claimed to have no effect on cell size, eliminating the need for foam or heat stabilizers. Ultimate foam density depends only on borohydride concentration, which runs about 0.4%. Foams can be formed at room temperature or above. Setting, on the other hand, requires a 350°F temperature. When the plastisol expands at room temperature, cell structure is said to remain unchanged through the fuse and cool cycle.

Sodium borohydride is made by reacting hydrogen gas with metallic sodium dispersed in mineral oil to form sodium hydride, and then reacting this compound with methyl borate.

Mid-June construction photo of U.S.I.'s million gallon phosphoric acid storage tank.

CONTINUED

Storage Tank

source, and the most concentrated source (52-54%), of P_2O_5 available commercially. Finally, it can be a very economical source of P_2O_5, depending on location.

Because of these characteristics, wet-process phosphoric acid offers fertilizer formulators several important advantages: large quantities of ammonia can be neutralized, because of the high acidity characteristic. High analysis grades can be formulated because of the high concentration characteristic. And for granular goods, this raw material gives rugged granules, well suited to subsequent handling, without the addition of granulation aids.

Now, with the addition of large-scale storage facilities, the U.S.I. plant at Tuscola will be better able to handle the growing demand for this economical raw material by formulators in its market area.

CONTINUED

Polyethylene Extractor

chamber. Underflow and overflow ports connect the sections, for flow from stage to stage.

The box — and the partitions which separate the sections and the settling and antechambers within the sections — are made of polyethylene sheets. Each side of the box is one piece, as is the entire bottom. After assembly of box and partitions, all joints were reinforced and made water-tight by welding with molten polyethylene.

Mixing chambers are made from polyethylene cups, and polyethylene tubes welded to these cups act as inlets and outlets. Each mixing chamber contains an impeller assembly, consisting of saran mounting plate, stainless steel bearing, polyethylene-coated stainless steel shaft and a polyethylene impeller.

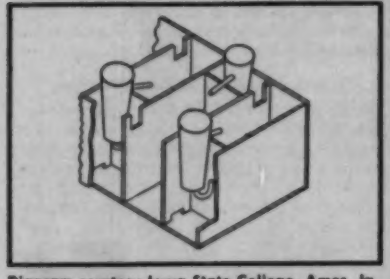

Diagram courtesy Iowa State College, Ames, Ia.

Three U.S.I. Sales Offices Get New Managers

E. RICHARDSON

J. HALLOWELL

J. PUTNAM

Edward C. Richardson has been appointed U.S.I. Chicago Sales Division Manager, succeeding George H. Stanton who has been named Director of Field Sales for the company. Mr. Richardson has been Sales Division Manager for U.S.I.'s Boston office since 1950. He has been with the company's sales organization since 1940.

Jesse H. Hallowell succeeds Mr. Richardson as U.S.I. Boston Sales Division Manager. He has been with the company since 1953, first at the Tuscola, Ill. plant and most recently at the Chicago Sales office.

John A. Putnam, formerly U.S.I. salesman in the Atlanta, Ga. area, has been promoted to Manager of U.S.I.'s Atlanta office.

ATTENTION: Users Of Industrial Alcohol

As of July 1, 1959, a carrier permit is no longer required to transport tax-free, specially denatured and undenatured alcohol, including tax-free distilled spirits. For many years the Internal Revenue Code, and regulations issued under it, required a permit for such transport. The Excise Tax Technical Changes Act of 1958 (Public Law 85-859) which went into effect July 1, 1959 revoked the statutory requirement for permits.

As of the close of business on June 30, the assistant regional commissioners automatically terminated all outstanding bonds covering carrier activities. No further action is required by carriers.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Deodorant for industrial use, said to be odorless and to control residual odors without paralyzing olefactory nerves or masking, is now on market. Identified as quaternary ammonium compound, material has been used in hospitals, found to inhibit mold, mildew growth. **No. 1500**

Carbon wool — pure carbon in fiber form — can now be obtained in 6 standard types plus special grades. Said to have unusual combination of properties: low ash, color and sound absorption, heat resistance, inertness. **No. 1501**

Boron trifluoride neutron detectors, in wide range of sizes and several cathode materials, are now available. Detect slow neutrons by $B^{10}(n,\alpha)$ reaction. Can also detect fast neutrons by using moderators around detectors. **No. 1502**

Crystalline DL-glyceraldehyde 3-phosphate diethylacetal (GAP) now available in research quantities. Can be converted to DL-glyceraldehyde 3-phosphate, important in metabolism, respiration, fermentation, energy transfer. **No. 1503**

Booklet of conversion tables for metric and U.S. customary units of length, weight and volume can now be purchased. Contains conversions: mm-in., cm-ft., m-yd., g-avoir oz., kg-avoir lb., troy oz.-g, ml-fl. oz., l-US gal. **No. 1504**

New hydrazine flux for soldering electrical and electronic equipment is said to leave no rosin residue which is costly to remove; to be noncorrosive, insuring corrosion-free joints; to permit prefluxing. **No. 1505**

New adhesive for adhering paper labels to polyethylene containers has been developed. Claimed to form permanent flexible bond with all polyethylene surfaces and be be fast-grabbing, with good shock resistance and aging qualities. **No. 1506**

Silicones and their uses are covered in new catalog. Uses described include: rubber products, cosmetics, polishes, electrical insulation, water repellents, textile finishes, lubricants, release and antifoam agents. **No. 1507**

Newly-formed abstracting service supplies, at a charge, technical abstracts on drugs, cosmetics, toiletries, foods, plastics, paints and advertising. Abstracts supplied on index cards. **No. 1508**

Industrial fatty acids — their chemistry, production, processing and applications — are covered in comprehensive new 250-page book which can be purchased. Important commercial derivatives are also discussed. **No. 1509**

PRODUCTS OF U.S.I.

HEAVY CHEMICALS

Phosphatic Fertilizer Solution: wet process phosphoric acid.
Ammonia, Anhydrous: commercial & refrigeration. Tank cars or tank wagons.
Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions
Sulfuric Acid: all strengths, 60 Baume to 40% Oleum. Also Electrolytic grade to Federal specifications. Tank cars or tank wagons.
Caustic Soda, Chlorine
Sodium, Metallic: cast solid in tank cars, steel drums, pails; bricks in barrels, pails.
Sodium Peroxide

OTHER PRODUCTS

PETROTHENE® Polyethylene Resins
Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Riboflavin USP, Intermediates.
Alcohols: Ethyl (pure and all denatured formulas); Anhydrous and Regular Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL PE.
Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.
Animal Feed Products: Antibiotic Feed Supplements, Calcium Pantothenate, Choline Chloride, Special Liquid CURBAY, Menadione (Vitamin K_3), DL-Methionine, MOREA® Premix, Riboflavin Products, U.S.I. Permadry, Vitamin B_{12} Feed Supplements, Vitamin D_3.

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Division of National Distillers and Chemical Corporation
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THE VALVE AND FITTINGS ANSWER CORNER

Send in your questions on stainless valves and fittings to Carl Tylka, Cooper Alloy Technical Service Director.

Q. *Is it possible to obtain a valve which, like a globe valve, possesses linear throttling characteristics, but which also, like a gate valve, has low fluid pressure drop across it when fully opened?*

A. Not throughout the entire flow range of the size valve being considered. A very close approximation, however, may be attained with a Flex-Plug type design (a unique new valve patented by Cooper Alloy), which provides linear throttling response up to 90% of full valve flow. The 10% balance of the upper flow region would exhibit a typical gate valve flow pattern.

Q. *How can one prevent oxidation of active ferrite ion on the fluid side of a cast stainless valve body?*

A. This type of corrosion is commonly found on untreated cast stainless surfaces only, and may be caused by foundry, machinery, and handling techniques. Proper pickling and passivation with thorough mechanical cleaning will generally rectify this, though in some cases actual weld repair of the contaminated surface is required. Since this is a surface condition only, machining or grinding will also help.

Q. *What type of valve do you recommend for manual-control services where minimum pressure drop is required?*

A. In the absence of more detailed knowledge of the problem, I would tentatively recommend an angle valve. The pressure-drop characteristics of this type valve are less than 50% those of conventional globe valves.

Q. *Is it advisable to specify installed valve position on an order?*

A. Definitely. By inclusion of this information, definite design considerations can be incorporated, especially in cases where backseat leakages are critical and mechanical valve operation is involved.

Q. *Is it advisable to install valves smaller than the accompanying pipe sizes?*

A. Where flow and pressure considerations so permit, it is not only advisable but also economically beneficial.

Q. *Why aren't valve bodies with butt weld end connections made shorter?*

A. To prevent distortion of the seating surfaces during installation. The longer length is required for heat dissipation during welding.

Above left, Cooper Alloy 16" cast stainless gate valve ready to receive gear motor drive; lower left, Cooper Alloy 12" cast check valve. Both are rated for 2900 psi service at 670°F. Official AEC photo above shows them in place in nuclear process line.

Cooper Alloy cast stainless valves spurt ahead of competition to win acceptance in AEC's Spert III reactor program

Cast yield strengths of 23,000 psi, plus cost savings of 40%, do the trick!

This is a Cooper Alloy success story in another "first": casting of stainless valves and fittings to strength levels actually surpassing those previously possible only in forgings—and doing it all at a 40% saving to the customer!

The story starts, naturally, with the AEC's valve and fitting specifications, which are rugged indeed. They have to be certified to function continually at elevated pressures and temperatures (2500 psi, 670° F.), under which conditions leakage, corrosion, and other operational problems are magnified enormously over those encountered in normal process work.

Prior to turning to Cooper Alloy, the contractor for the AEC cancelled a large valve order from another supplier, because the latter could not meet the exacting physical specs without changing the material specs. Cooper Alloy was given the order on the basis of producing to meet AE and AEC specs. Cooper Alloy valves and fittings are currently in operation in the AEC's Spert III installation at Arco, Idaho. Included are nuclear fittings, and motor and manual operated gate, globe, and check valves in various sizes.

How does Cooper Alloy do it? Through the use of the most advanced foundry methods, meticulous attention to conditions, and an exact balance of chemical composition to develop the maximum strength characteristics inherent in the complex structure of stainless alloys. All products, naturally, are elaborately tested and guaranteed before delivery.

As if the AEC's specs were not stringent enough, there is now a bonus to the story: during production, Cooper Alloy technicians worked out ways of producing cast strengths higher than those required, and proceeded to produce all fittings and valves to these higher, self-imposed standards—at cost savings of 40% over forged valves and fittings!

Unusual, yes, but not to Cooper Alloy. It's typical of the quality bonus you get when you buy from Cooper Alloy. For further information, write to Cooper Alloy Corporation, Hillside, N. J.

For more information, turn to Data Service card, circle No. 7

• *Working with you and your contractor—*

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Write for free copy of new Yuba Bulletin 858-CEP for full details.

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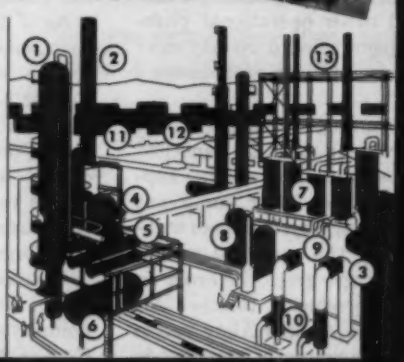

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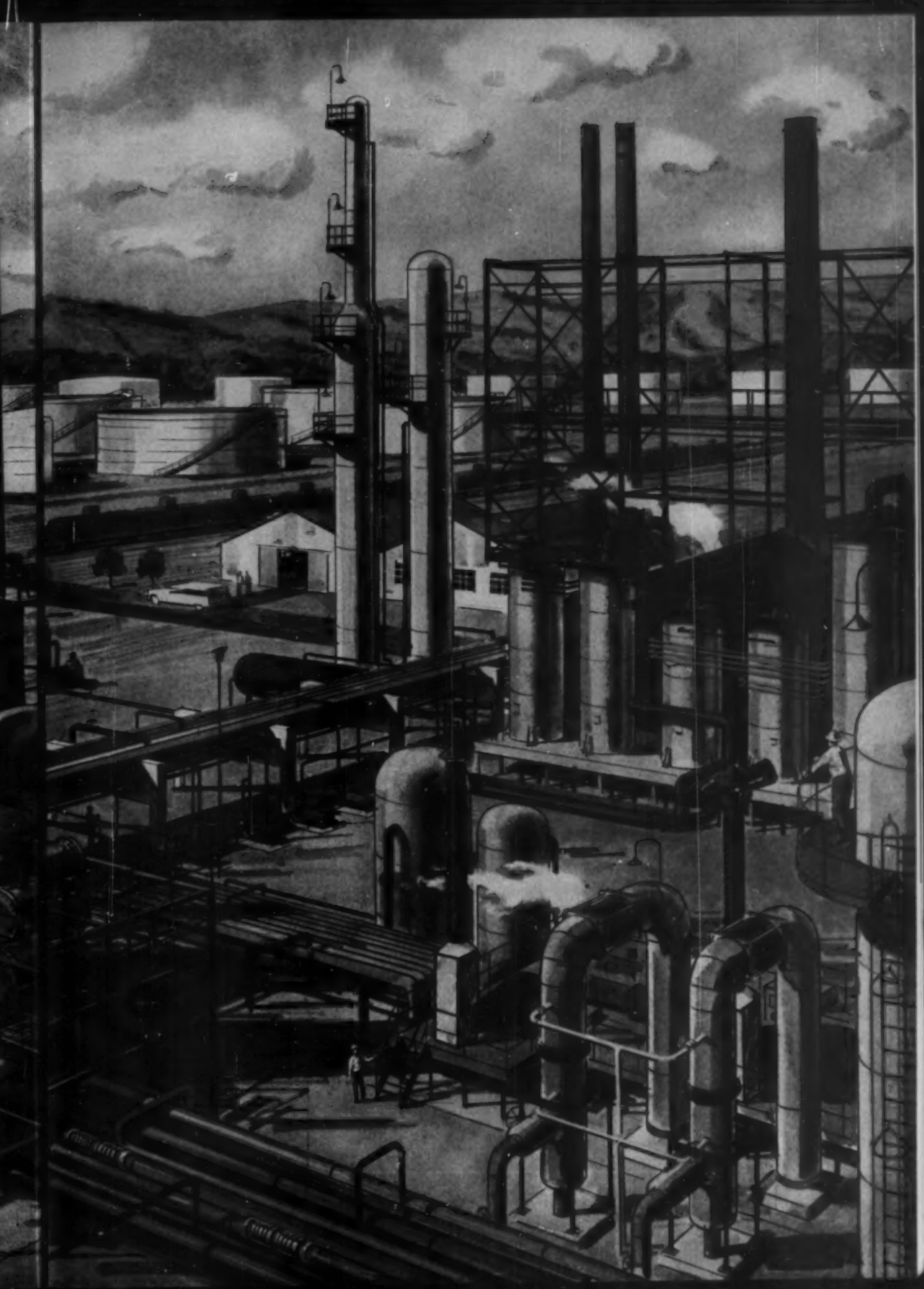

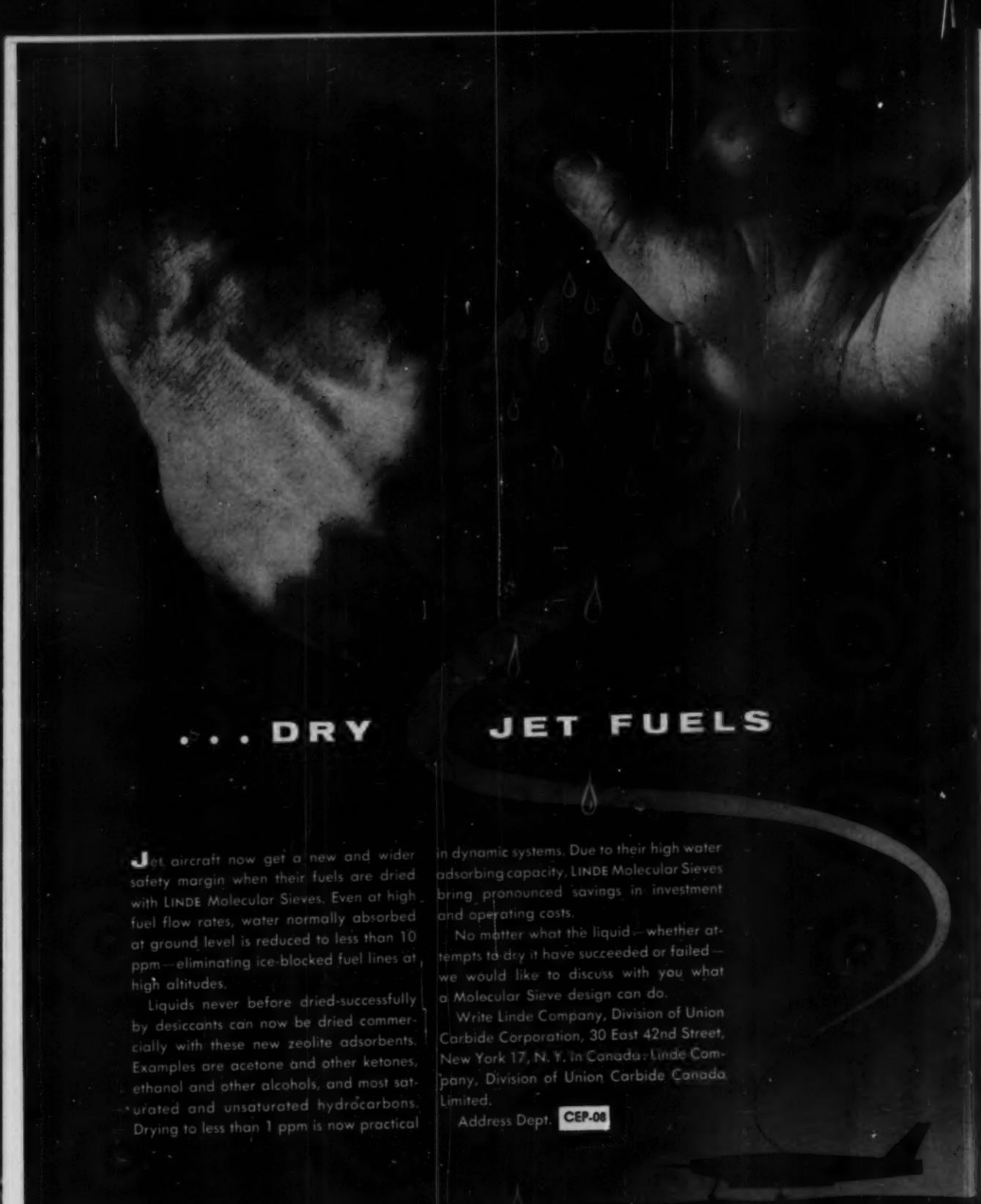

. . . DRY JET FUELS

Jet aircraft now get a new and wider safety margin when their fuels are dried with LINDE Molecular Sieves. Even at high fuel flow rates, water normally absorbed at ground level is reduced to less than 10 ppm—eliminating ice-blocked fuel lines at high altitudes.

Liquids never before dried-successfully by desiccants can now be dried commercially with these new zeolite adsorbents. Examples are acetone and other ketones, ethanol and other alcohols, and most saturated and unsaturated hydrocarbons. Drying to less than 1 ppm is now practical in dynamic systems. Due to their high water adsorbing capacity, LINDE Molecular Sieves bring pronounced savings in investment and operating costs.

No matter what the liquid—whether attempts to dry it have succeeded or failed—we would like to discuss with you what a Molecular Sieve design can do.

Write Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Address Dept. CEP-08

Linde MOLECULAR SIEVES

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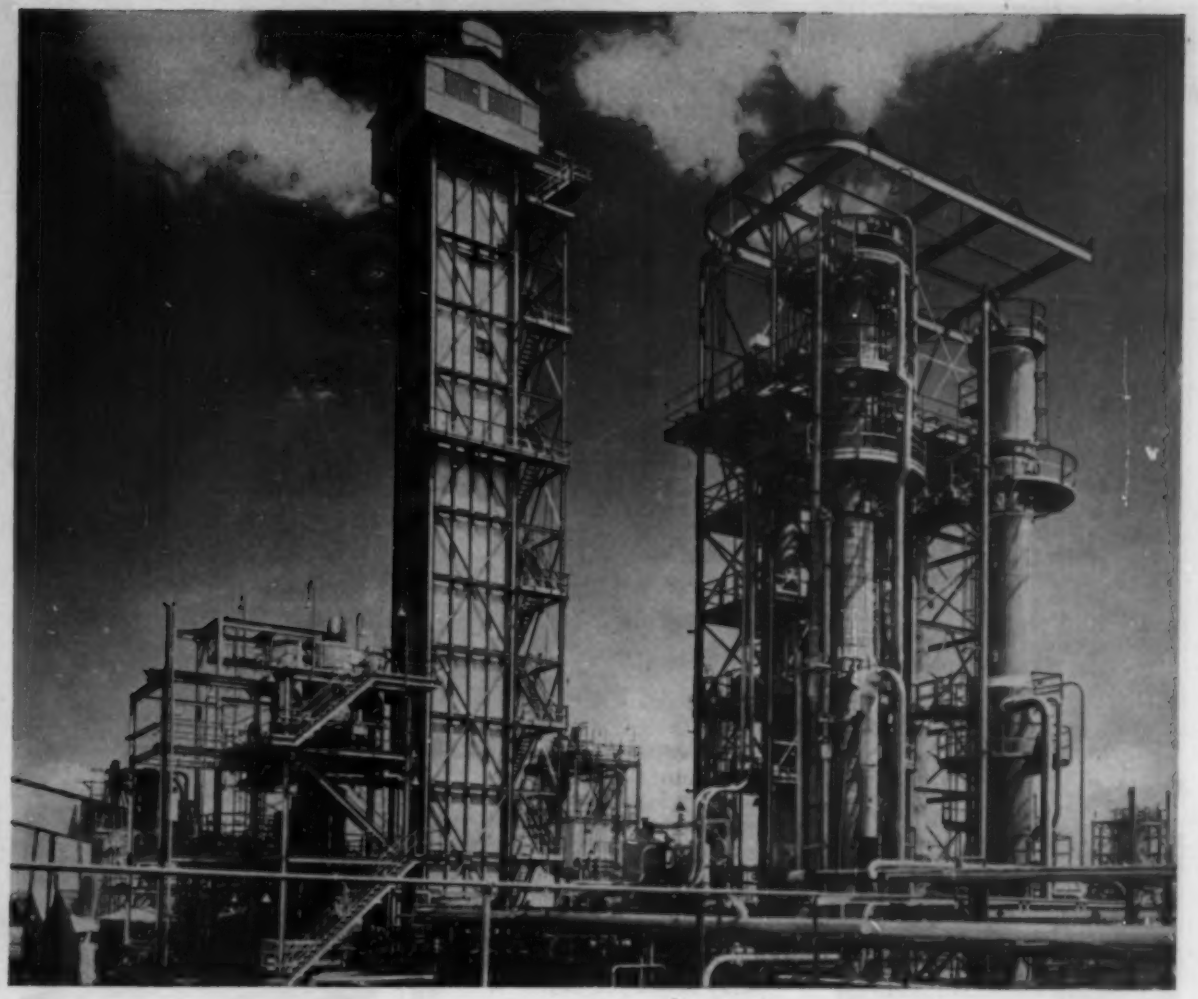

A precedent-setting new concept in engineering service

The Pechiney-Grace Urea Process by Foster Wheeler

Now Pechiney's basic urea synthesis, Grace's operating experience and Foster Wheeler's engineering design and construction experience are available as a totally new packaged service to licensees.

It's a unique package, giving you:

- a total recycle process covered by one licensing agreement, from feed end through finishing operations, yielding urea of the highest purity.
- the benefits of experience gained by W. R. Grace in modifying and improving the original Pechiney Process and operating a full-scale plant for four years.
- Foster Wheeler's experience in originally bringing the Pechiney Process from pilot plant to full-scale commercial operation, and working with Grace engineers on subsequent improvements which created the Pechiney-Grace Process.

The new license package also makes available for the first time a new ammonia recovery system—currently saving 10-15 tons a day for Grace, and a highly efficient purification system. For information write to: *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.*

FOSTER WHEELER

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For more information, circle No. 49

For more information, turn to Data Service card, circle No. 102

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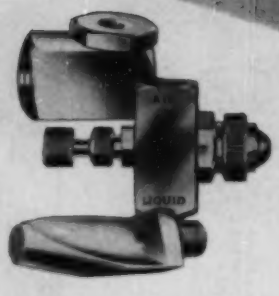
Whatever your application might be, Spraying Systems Co. offers spray nozzles to meet your need exactly. Over 12,000 standard nozzle types and capacities . . . to obtain whatever spray characteristics and capacities you desire in spraying, relative to any combination of liquid physical and chemical qualities.



RESEARCH

As a part of its own plant operation, Spraying Systems Co. maintains its own research facilities, for the continuing study of new spray nozzle designs, materials and applications. The many advantages of research are an inherent quality of every Spraying Systems spray nozzle you buy.

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Complete information on spray nozzle types, capacities and performance characteristics are available in reference catalog form. Data Sheets on hundreds of basic applications are also yours for the asking. You will find Spraying Systems a reliable reference source for any information concerning spray nozzles and their application.

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For more information, turn to Data Service card, circle No. 38

industrial news

A new sewage disposal system, using the method known as the Zimmerman Process, is being adopted by the city of Chicago. A plant built with a capacity of 200 tons of sewage sludge solids a day, will consist of four complete units of 50 tons each, and a turbo-generator unit for developing power. Scheduled to be ready for use in 24 months, the facility will be constructed by Sterling Drug, originators of the process, under a contract with the Metropolitan Sanitary District of Greater Chicago.

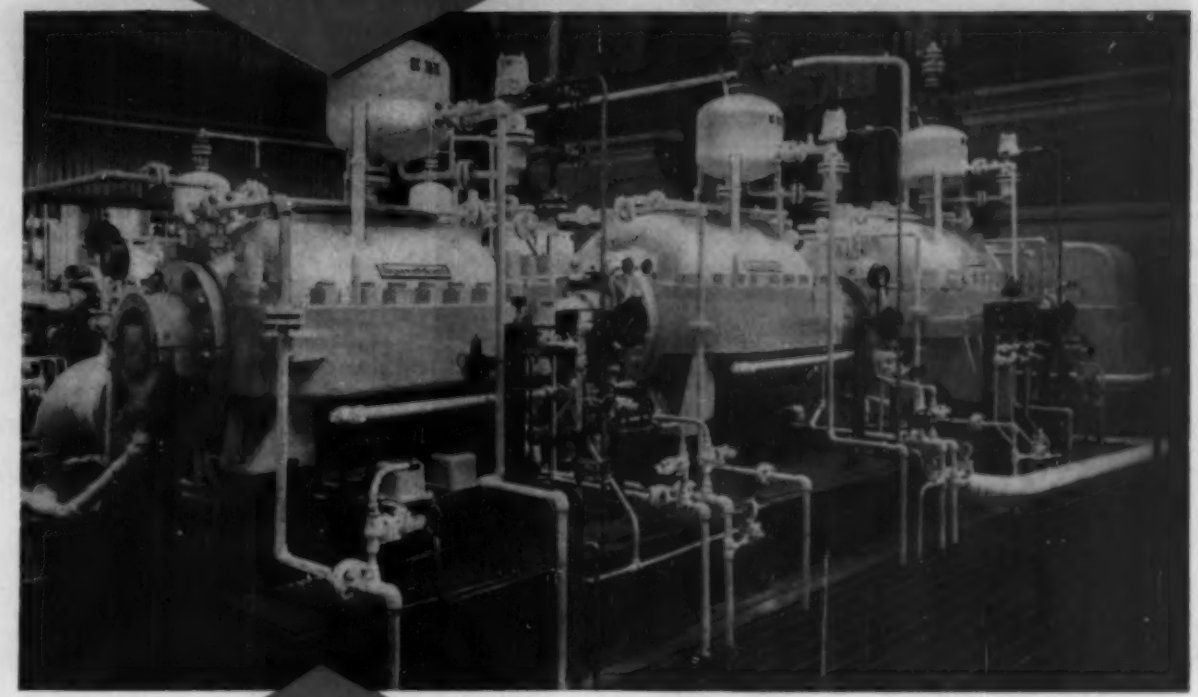
The new combustion method functions without conventional filters, chemicals and incinerators (see CEP March '58), and when finished will constitute more than 20 percent of the sanitary district's total treatment capacity.

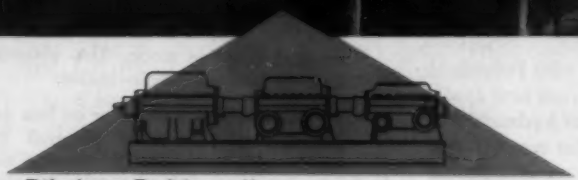
Work also begins shortly on a sewage sludge disposal system for the city of Wheeling, West Virginia. The 5 6 ton capacity plant will also use the Zimmerman Process.

A sour gas processing and sulphur extraction plant with a rated capacity of 370 long tons a day has gone on stream in Okotoks, Alberta, Canada. Jointly owned by Texas Gulf Sulphur, Devon-Palmer Oils, and Shell Oil of Canada, the new installation's gas gathering system, sweetening plant and sulphur conversion units are designed to process 30 million cubic feet of sour gas daily. Sulphur extracted from the plant is sold in the area, while commercial gas also goes to a Canadian firm.

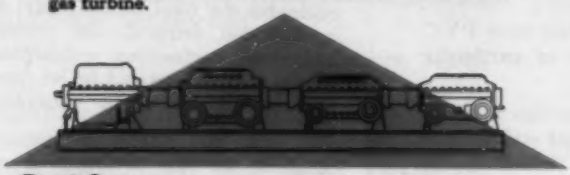
A plant producing acetylene and ethylene from liquid hydrocarbons will be established at Niihama City, Japan. Under an agreement between the Japanese firm, Sumitomo Chemical, and Société Belge de L'Azote et des Produits Chimiques du Marly, Liege, Belgium, the SBA process will be used.

Putting the PRESSURE on Ethylene Production...

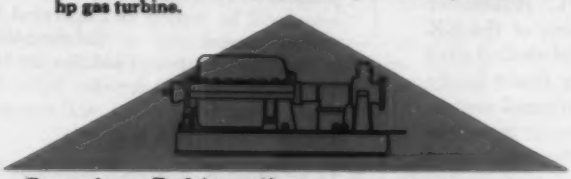




Ethylene Refrigeration: Three multi-stage, horizontally split I-R centrifugal compressors, handling ethylene gas at 396 psig discharge, driven by 12,150 hp gas turbine.



Feed Gas: Four multi-stage, horizontally split I-R centrifugal units compressing 10,750 cfm of hydrocarbon feed gas to 525 psig discharge, driven by 12,150 hp gas turbine.



Propylene Refrigeration: One single-stage vertically split and one multi-stage horizontally split I-R centrifugal compressor handling 17,900 cfm at 265 psig discharge, driven by 12,150 hp gas turbine.

Three Trains of Ingersoll-Rand Centrifugal Compressors help P.C.I. boost ethylene output at Lake Charles plant

THE new plant of Petroleum Chemicals, Inc., at Lake Charles, La., can produce one hundred thousand tons of ethylene per year, making it one of the country's major sources of this vital component for the chemical and plastics industries. Built by the Lummus Company, this P.C.I. plant features the latest technology and equipment for ethylene production.

To handle the various pressures required, nine Ingersoll-Rand centrifugal compressors are installed in three trains, each with its own gas turbine drive. The installation for ethylene refrigeration, shown in the photo above, consists of three multi-stage, horizontally split centrifugal compressors. This and the other two multiple-unit installations, all under one roof, are diagramed at the left. All of these centrifugals are designed to permit a 50% increase in plant production.

P.C.I. facilities at Lake Charles and the adjoining Calcasieu Chemical Corporation's plant (built and operated by P.C.I.) also include two other I-R centrifugals, eleven I-R reciprocating compressors totaling more than 23,000 hp, two I-R Axi-compressors and ninety-two I-R centrifugal pumps.

For information on equipment best suited to *your* compression requirements—centrifugal, reciprocating, axial-flow rotary or ejector—contact your nearest I-R engineer. Sizes and types range from vacuums of 5 microns to discharge pressures of 35,000 psi.

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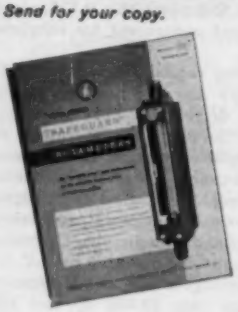
For more information, turn to Data Service card, circle No. 47

SK "SAFEGUARD" ROTAMETERS

New Bulletin 18RG describes SK's line of "Safeguard" Rotameters and gives detailed instructions for liquid and gas sizing. A special sheet lists fluids for which PVC is recommended. Send for your copy.



SK "Safeguard" Rotameters with Polyvinyl Chloride (PVC) end fittings are now available for measuring the flow of hydrochloric acid, sulphuric acid, and the many other chemicals for which PVC is recommended. As a matter of fact, these new Rotameters are already being used for corrosive fluid service with excellent results.

Two facts regarding this new PVC "Safeguard" Rotameter are of particular importance.

First, this instrument provides a Rotameter with chemical resistant end fittings and rotor at much less cost than a similar instrument with these components made of other special corrosion resistant materials.

Second, the Fig. 18275 "PVC" Rotameter incorporates all of the features of the SK "Safeguard" line—one piece fabricated steel case, tube and rotor versatility, heavy safety glass windows, adaptability to panel mounting and to electric or pneumatic transmission for remote recording and controlling of fluid flow, and others.

QUICK DELIVERY FROM STOCK

For Immediate Delivery, Standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Heights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.

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For more information, turn to Data Service card, circle No. 84

industrial news

Construction has started on a multi-million dollar addition to the production facilities for Kodel polyester fiber at the Tennessee Eastman Co., Kingsport, Tennessee. The expansion, which will bring capacity to 20 million pounds, is in response to demand for the new polyester fiber on the part of textile mills and their customers. The plant is scheduled to go on-stream in mid-1960.

An agreement has been reached whereby W. R. Grace acquires Hatco Chemical. Hatco, an ester and synthetic lubricants producing company, located in New Jersey, will be operated as a division of Grace.

A $17 million refinery building program goes into effect at Union Oil of California, with new facilities expected to be in operation within fifteen months. Facilities to be built are: a 14,000 barrel per day catalytic reformer to produce a high octane blending gasoline component; a Unifiner to re-treat the feedstock to the new catalytic reformer; another Unifiner to upgrade heavy catalytic cracked gasoline stock. Also planned is a carbon monoxide boiler.

A computerized system for on-line gas dispatching control is planned for installation in the Public Service Co. of Colorado. The GPE Controls LIBRATROL—500 Process Control System, said to be the first of its kind, computes the total hourly daily and accumulated demand, and provides additional engineering calculations. The system is expected to be especially suitable for use in petrochemical industries.

A plant for the development and eventual production of high energy chemical fuels for rocket and missile propulsion systems, acquired by Celanese, will be owned and operated by Amcel Propulsion, a Celanese-controlled corporation. Facilities at the 1300-acre site in Asheville, N.C., include a test firing range, and research and development laboratory.

In response to increased demands for maleic anhydride, plans to increase production are underway at Allied Chemicals' National Aniline Division. Operating facilities are being expanded at Moundsville, West Virginia, and Buffalo, New York. Both expansions, scheduled for completion late this year, will provide increased supplies of maleic anhydride in rod, tablet, and molten form.

For more information, circle No. 63

CB&I CRAFTSMANSHIP IN STEEL

...the product of Engineering with Imagination

This unique vacuum tower was fabricated and erected by CB&I to meet an exacting set of performance requirements at the El Paso refinery of Standard Oil of Texas:

FEED: 13,000 barrels per day, reduced crude

NOMINAL PRESSURE: 2 pounds per square inch, absolute

OPERATING TEMP: 750 degrees Fahrenheit (approx.)

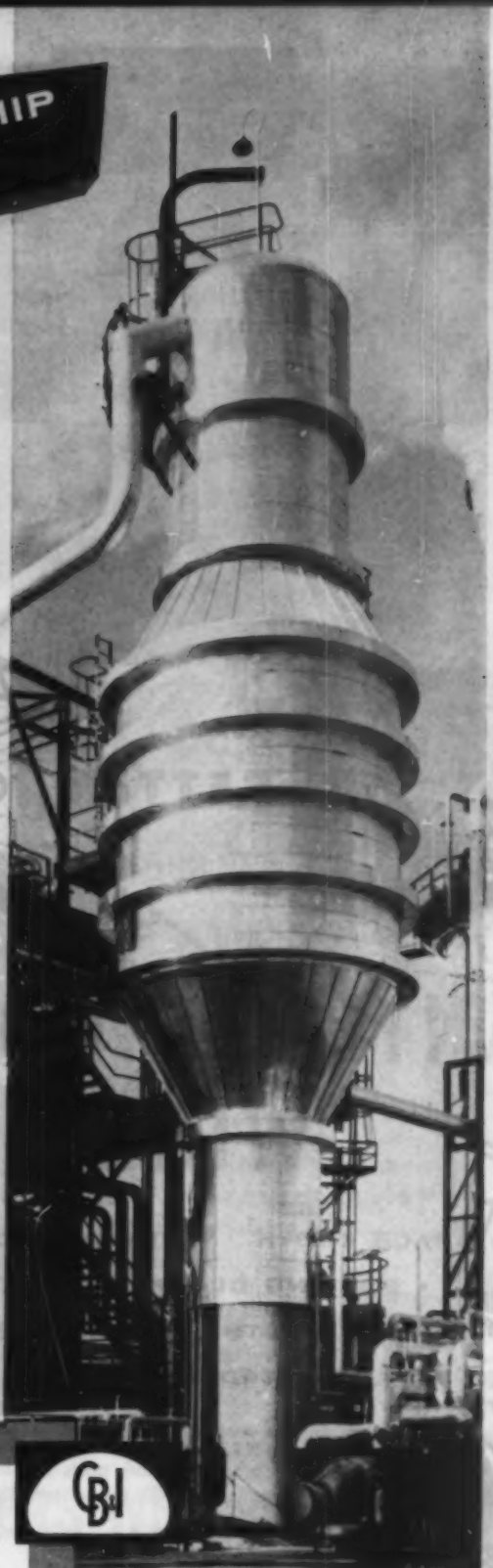
HEIGHT: 87 feet

DIAMETER: Varies from 8 to 18 feet

What is CB&I *Craftsmanship in Steel?* This unusual structure is a good example. It is engineering tempered with imagination. It is close attention to metallurgical control and structural detail. It is careful customizing of structure to process. Most important, it is *experienced coordination* through *all* phases of engineering, fabrication and erection.

These *coordinated services* are the reason why leading refiners rely again and again on CB&I for their critical tanks, towers and processing structures. For more information, write your nearest CB&I office, today. Ask for the brochure: *CB&I Craftsmanship in Steel.*

CB&I-built vacuum tower designed for reduced crude feed of 13,000 bpd. CB&I also built a reactor and regenerator, furnished through Fluor Corporation, Limited, for Standard Oil of Texas.



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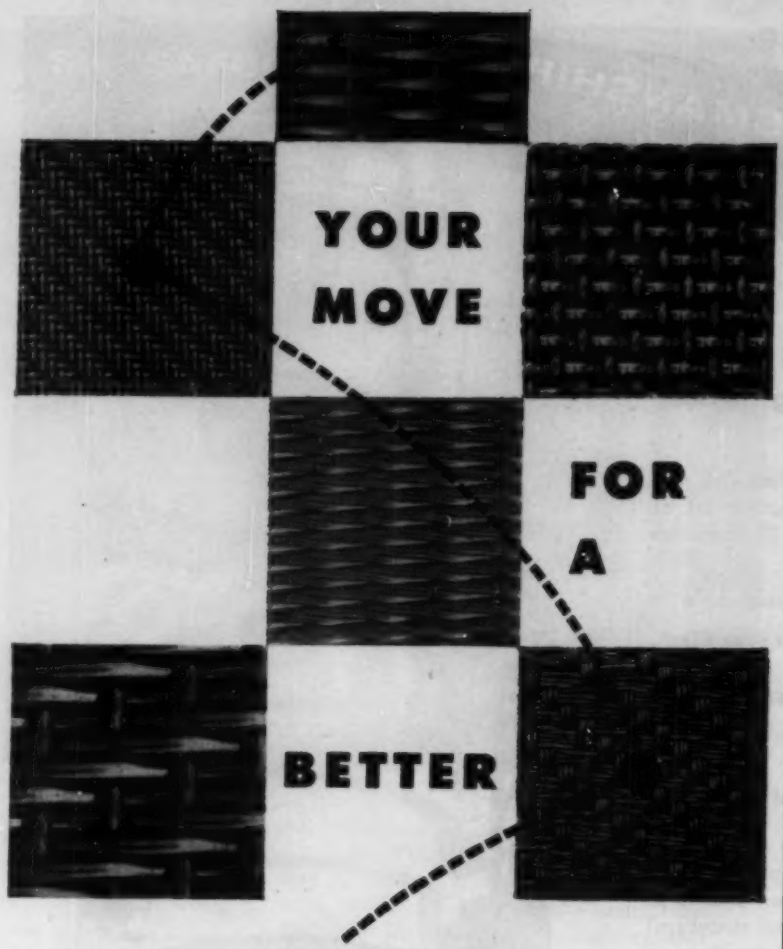

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about our authors

Martin L. Nadler *(The Problems of Plant Startup)* has been heavily involved in process development and plant startup at Dupont, where he has spent his entire working life. Nadler's all-around experience with Dupont includes work in several different divisions. Starting his career in 1941 with the Organic Chemicals Division, he took part, during World War II, in the Manhattan District Program (the name given to Dupont's contribution to the atomic energy program). He is now with the Elastomer Chemicals Division engaged in market development.

Everett Gorin and **H. L. Recht** were co-workers at Consolidation Coal Co., Library, Penna, when the research work on *(Fuel Cells)* was done. Gorin is now manager of process research, Research and Development Division of Consolidation Coal; while Rechter is with Atomics International, Canoga Park, California.

Ralph A. Morgen *(Chemical Engineering Education in the USSR)* was one of a group of American exchange delegates in the education field who went to the Soviet Union in the winter of 1958. Purpose of the mission, which was organized by ASEE at the invitation of the State Department, was to make a study of Soviet Engineering education. The tour took in several representative schools, and this report is based on Morgen's first-hand observations. Morgen is at present director of the Purdue Research Foundation, and a member of the faculty of the university. He was formerly head of the Department of Chemical Engineering at the University of Florida.

Ray H. Jebens *(The Ball Mill for Pigment Dispersion and Grinding)* has been with Patterson Foundry and Machine for five years, and is currently manager of application research for the company. He has fifteen years of service with Dupont, starting out in their Engineering Department right after completing graduate work at Columbia.

A heavy water fractional distillation plant is scheduled to go on-stream this fall at Chalk River, Ontario, under a contract awarded by Atomic Energy of Canada to Badger. The plant will be used to reconcentrate heavy water supplies downgraded by light water contamination. The distilling equipment has been specially designed to minimize loss through leakage or vaporization.

In direct competition . . .

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LEAD in product quality in operating economy

1. BETTER DEWATERING ON CENTRIFUGE OR FILTER
2. LOWER DRYING COST
3. ELIMINATION OF DUST LOSS
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6. ADDED SALES APPEAL

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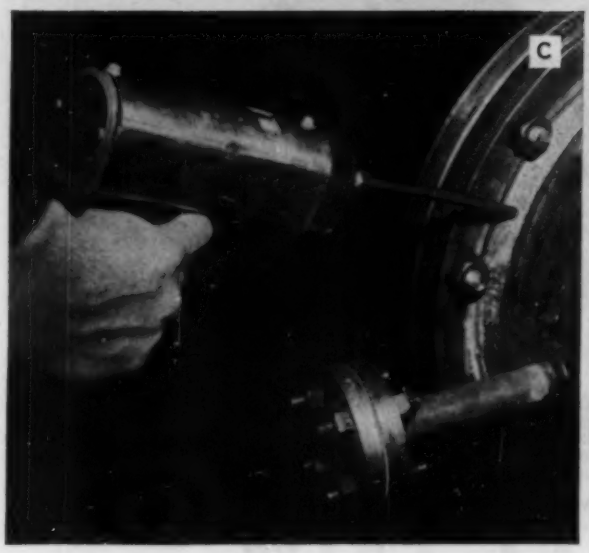

Modern techniques bring new benefits

Whatever is new in metallurgy, welding, or testing is sure to absorb the attention of Downingtown experts—especially when it helps us produce better processing equipment for you. Here are some of the modern techniques you would see on a trip through our shop. Write for handy index to the ASME Code.

A **Skin-deep**—When paint thickness is vital to product protection against corrosion, this instrument tells us exactly how thick the paint application is.

B **Fresh from the oven**—Heated to 250°F to drive out water vapor, these welding electrodes won't contaminate weld metal or adjacent plate with water-released hydrogen.

C **Sniff! Sniff!**—No leaks here... if there were, the Halide leak detector would react fast as it sniffs the seams and joints of a vessel pressurized with gas.

D **A penetrating analysis**—Special dye, sprayed on weld after back-chipping, reveals microscopic cracks so they can be eliminated before weld is completed.

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DOWNINGTOWN IRON WORKS Hackney

For more information, turn to Data Service card, circle No. 12

Industry watches Cuban sugar situation

Half of the world's free market sugar is supplied by Cuba. Therefore, current negotiations between U. S. sugar producing firms and the Cuban Government on land expropriation under the new Cuban Agrarian Law are being watched with some apprehension by business interests all over the world. Particularly affected are sugar-based chemical processing industries in the United States. Also concerned with the outcome of the negotiations are other American industries in Cuba, such as Freeport Sulphur's $120 million nickel-cobalt extraction plant now nearing completion in Moa Bay, Cuba. In the sugar industry itself, feeling is that sugar producing interests outside Cuba might not be averse to picking up Cuba's share.

Under the new Agrarian Reform Law, excess land is to be appropriated and divided among landless Cuban citizens. This is the provision of the law which most directly affects American sugar interests in Cuba, which total about 40 percent of the sugar producing capacity in the country. The remaining 60 percent is Cuban owned. Terms of the law, the basis of the present negotiations, state that compensation to former owners will be based on the assessed value of the land for tax purposes prior to October, 1958. This is to be payable in 20-year government bonds bearing 4½% interest, the interest to be tax-free for ten years if invested in new Cuban industries. This is doubtless intended as encouragement to foreign industry to remain in Cuba, but the thinking of leading sugar economists and brokers in the United States is that tax values are assessed very low, thus apparently enabling the Cuban government to acquire land at prices below the real market value.

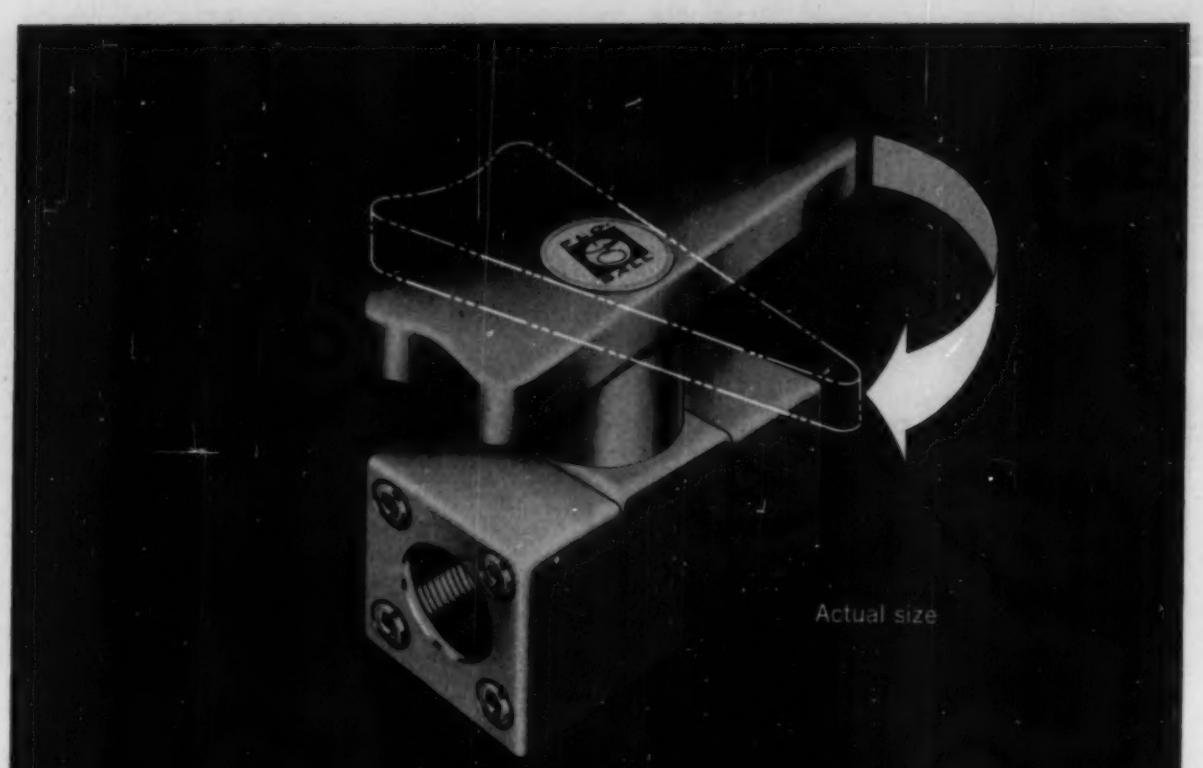
Maximum permissible land holdings are fixed at 1,000 acres except in the case of land used for rice, sugar, or cattle-raising where larger holdings are allowed. These holdings are subject to minimum yields per acre as fixed by the Agrarian Reform Institute. Ownership of property is limited to Cuban citizens or wholly Cuban-owned companies, although the Government can grant land to foreign individuals or companies when the Agrarian Institute considers this to be in the national interest.

Immediate result of passage of the new law was an appreciable drop in the value of shares in U. S. sugar producing companies in Cuba. The situation is now in such a state of flux that new plantings and development plans have been either postponed or suspended. This despite apparent attempts on the part of the Cuban Government to allay fears with the statement that expropriation of sugar land would be postponed for one year.

The free market price of sugar stands today at $2.55 per 100 lbs.; sugar producers are complaining that this is much too low to allow what they consider an adequate profit margin. The total annual world production of sugar is about 50 million tons. Of this total, about 44 million tons is "captive" in one way or another, that is to say it is allocated under a variety of international quota agreements and by import restrictions on the part of individual countries, including the United States. The remaining 6 million tons makes up what is called the "free market" sugar, which is free to flow into any market open to it. Obviously, any changes in Cuba's national economy will affect this market.

Cuba unquestionably has many serious economic problems. The bulk of the economy depends on this one product (80 percent of the country's foreign exchange comes from sugar, with the most significant percentages of the balance distributed between the tourist trade and the tobacco industry). Grave doubts have been raised as to whether the sugar industry can function efficiently if the large estates are broken up into small farms, particularly in view of the necessity for mechanization to produce efficiently, and the serious shortage of trained technical people. Yet, on the other hand, Cuba is a country of land-hungry people, and the Government's continued popularity depends on their support.

In what appears to be another effort to satisfy doubts that the Cuban Government can maintain and even increase output, Premier Castro offered the United States, through its Secretary of Agriculture, 8 million tons of sugar in 1961 at a price of 4 cents a pound. This compares with a value of approximately 5.4¢ F.A.S. Cuba in June of this year. While the offer itself was considered unacceptable, this fact, along with the postponement of the expropriation provision, and the continued negotiations, bear out the opinion of informed sources close to the sugar industry that Cuba will not take drastic steps at this point. The consensus is that while Premier Castro is possibly in a position to knock the props out from under the entrenched sugar interests in Cuba, he will not do so for the simple reason that he cannot afford to.



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opinion and comment

Technological Information—Government Responsibility?

One of the interesting by-products of the hearings recently held in Washington on creating a Department of Science and Technology was the great interest shown in scientific information. Of particular consequence was the frequent discussion about who was responsible for making scientific information available to those who best use it.

Scientists and engineers of the United States, after years of supporting their own technical publications, as do other professions such as the doctors, teachers, economists, etc., have more than a casual right to evaluate whatever decisio. is reached and to make their opinions known.

The need for technical information has usually surpassed the financial ability of professional organizations to provide it. This must be recognized even in the face of several notable pioneering ventures. The American Society for Metals, for instance, gave a $75,000 grant to Western Reserve University for a center on documentation and communication, which has led to important techniques for coding scientific documents and in developing a machine to search out such information. We have, too, the remarkable performance of the American Chemical Society in publishing *Chemical Abstracts* these many years, without which chemical science would be much further back on the path.

Normally the mechanism of meeting presentation followed by publication guaranteed that most worthy scientific contributions came to the attention of those best fitted to use them—the experience of Willard Gibbs to the contrary notwithstanding. However, things are not normal.

Science and technology are vital adjuncts to national defense, and this condition has raised its own iron curtain of secrecy. Secrecy breeds research duplication, as does the practice of consigning countless reports to files or to limited circulation. Even when secrecy is dropped, the immense amount of material suddenly made available creates great gaps in the knowledge of those trying to catch up. Without a steady flow of data and progress reports, the newcomer to a field has to exert great diligence to penetrate the coterie of esotericism which the experts have built up as a result of talking only to one another.

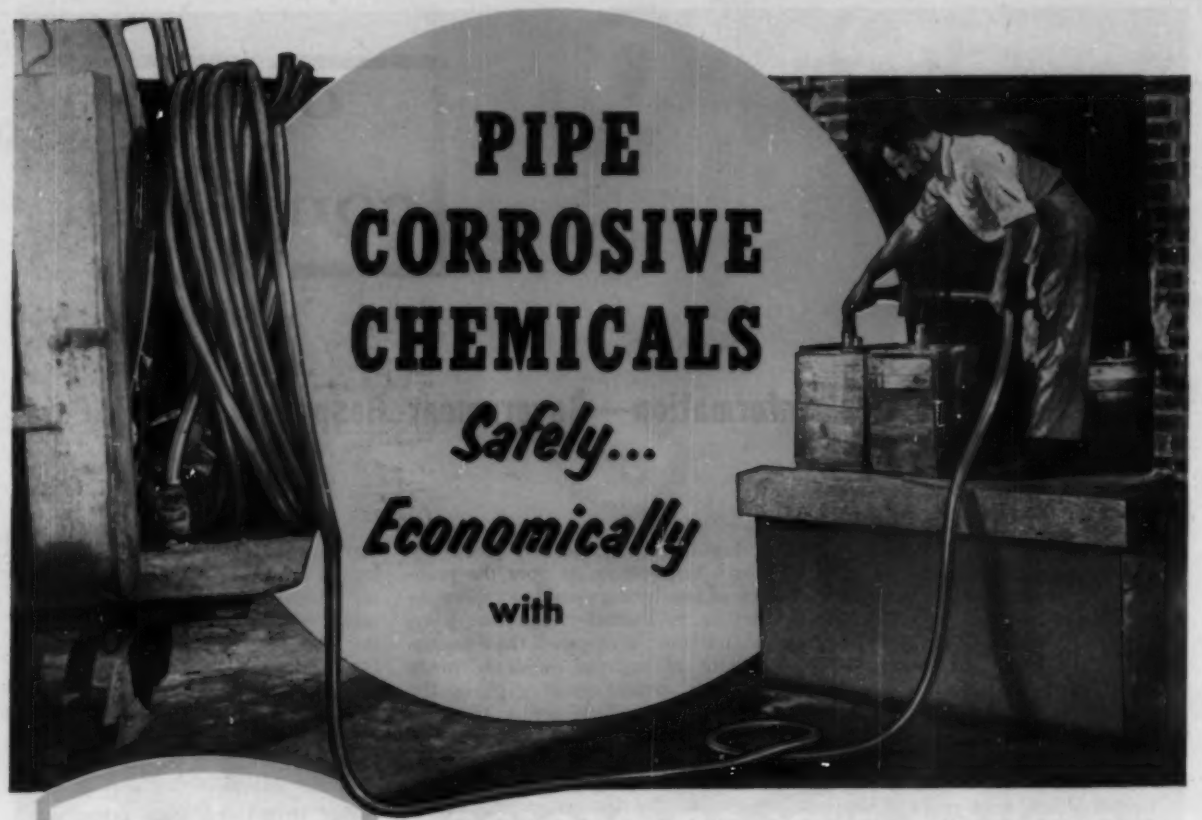
There is no doubt as to the need for an information program which would enable serious workers to follow current research and to know with certainty what has been done before. Stories are told of directors of engineering who have discovered their staffs working on programs that had been researched and rejected ten years earlier. Their staffs were not aware of what had been done because the original research report had lain buried in the company library. Such an error is, of course, not the fault of the technical literature. It is the fault of the company that did the original research and either refused to have the research made public or did not recognize the value of adequate library services.

The tremendous progress that Russia has made in the field of information abstracts was well detailed in testimony before the Senate subcommittee by James Rand, who pointed out that the central Russian agency (begun in 1952) for gathering the world's technical literature is divided into thirteen subdivisions and that by 1956 one subdivision, chemistry, was issuing more abstracts than *Chemical Abstracts*. Bear in mind that the Russians are doing this for thirteen divisions, which include such subjects as mathematics, geography, metallurgy, biological chemistry, electrical engineering, physics, etc. Is it any wonder that many who think about this say, and say bluntly, "This is a case for the Government"? As a matter of fact, the immensity of the problem does make it seem that the only solution is to turn it over to the United States Government, letting it pay the bills for scientific information.

But isn't there some other way? Would it not be logical for the chemical process industries to recognize the fact that information services are a modern necessity and, instead of depending on the Government, to see to it that funds are made available for such services?

There is no hope that professional societies will ever command enough income to do the job that they are being called upon to do. Fields are expanding too rapidly. The industrial leaders, however, could create their own study commission in the chemical field and, through some agency, make certain that there is the wherewithal, first, to study the problem and, second, to guarantee the availability of scientific and technical information. What would start as a service would undoubtedly in time return the investment a thousandfold in accelerated technical progress.

The problem is not merely one of company reports; the problem is that of prime scientific material coming out of colleges, Government installations, industry, foreign countries, etc. Certainly, with a deficit in the Federal Government for the year just ended of over twelve billion dollars, a realistic approach to the future makes it apparent that we ought to seek as many solutions outside the Government as we can. F.J.V.A.



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The problems of plant start up

Martin L. Nadler, of Dupont's Elastomer Chemical Department in Wilmington, introduces this special CEP feature on the problems of starting up a new plant.

The increasing size and complexity of many of the new chemical manufacturing units present special problems to the engineer and management. Such phases as design concepts for continuous flow manufacture, new instrumentation requirements, and the effects of automation have been treated extensively in recent publications. There are also special problems involved in the startup of a new chemical facility. These have received scant attention in the literature.

The four articles on the next 13 pages are condensed from papers presented at A.I.Ch.E.'s recent Atlantic City meeting. They provide a "worksheet" of the actual methods employed in four recent major startups. The summary reflects the viewpoints of operating supervision, the maintenance engineer, and the special role played by the process contracting firm which may have constructed the plant. In each case it is important to note the amount of detailed planning and training which preceded the actual startup.

A large chemical unit represents a major commitment of capital. It should not be allowed to stand idle or unproductive, assuming, of course, that the basic decisions on marketability of the product were sound. To achieve a design rate and design economy in minimum time requires an adequate number of trained personnel. During the course of startup it may become apparent that some phase of process, design, or construction is technically inadequate. In this case it is urgent that the startup organization be capable of diagnosing the problems quickly, and of taking corrective action.

The heart of good start up: quick analysis of troublesome areas and making modifications on the spot. (Photo courtesy of Dupont's employee magazine Better Living.)

Operator training in new plant startup

P. W. PONTIUS, P. A. VAN TASSEL, AND J. H. FIELD
Union Carbide Corporation
Institute, West Virginia

The proper training of chemical operators is becoming increasingly important in the startup of new plants. Here is a program in use at the Institute, W. Va., and Seadrift, Texas, plants, Union Carbide Chemicals. The program includes Basic training of new employees, and Specific job training of both new and experienced personnel. Safe, efficient, operation with a minimum of errors during startup is the primary objective. The development of a strong, flexible permanent operating organization can be the long range benefit.

Basic training of new employees

The previous occupations of new chemical operators may vary widely; from bus driver or shoe salesman, to farmer. It is necessary for them to make many personal adjustments to feel at home among the noises, odors, and vibrations of a chemical plant. A period of basic training prior to assuming operational duties puts the employee at ease, gives him confidence, and familiarizes him with the jargon so that he will more readily understand on-the-job instruction. It also orients him in the plant layout, acquaints him with the people with whom he will be associated (particularly his immediate supervisor), and helps him realize that he is working as a member of a team.

The Basic Training Manual is a part of the chemical operators' basic training program. It includes fundamental information which will contribute to a better understanding of *any* operating job. It explains the general responsibilities of the operator and discusses some of the equipment and operations which the average operator encounters daily. The manual is given to the operator to keep as his permanent reference. It contains no confidential information. The printed material must be interesting and, where possible, alive with illustrations.

The contents of the Basic Training Manual are summarized as follows:

The job. A chemical operator's job is to convert raw materials into useful products through the safe and efficient control of plant equipment. He is a better operator if he has a plan in mind to handle foreseeable emergencies and a sense of responsibility toward the Maintenance Department and the other auxiliary departments. He must have good housekeeping and safety habits, keep an informative unit log-sheet, and tell his relief operator pertinent factors about the present operation in his job assignment.

The equipment. Once the operator can visualize the internal mechanism of each piece of equipment, he will not have much difficulty in understanding the process within. This chapter includes the function and explains the internal mechanisms of valves, steam traps, strainers, pumps, compressors, turbines, motors, columns, heat exchangers, and separators which are common to most chemical units. Most equipment manufacturers are more than willing to provide pamphlets and bulletins that include pictures of cut-away models for use during the training session.

Phillip Pontius and his co-workers give here the results and interpretation of a comprehensive survey to identify basic factors involved in the development of people for plant operation.

The illustration indicates how such material may be utilized in the Basic Training Manual.

Materials. This chapter gives a general idea of the nature and use of air, gas, water, steam, and electricity; where they come from; and how they are distributed in the plant. For example, a flow sheet of the main air header in the plant is shown.

The science. A review of basic physics including such topics as: physical states, temperatures, pressure, density, specific gravity, heat, vapor pressure, flash point, and superheated steam. Following this, a review of basic chemistry may include explanations and information on acids, bases, salts, combustion processes, and composition of matter.

The processes. In general terms, fluid flow and heat transfer are discussed, along with distillation, adsorption, stripping, drying, cracking, gas compression, refrigeration, and steam generation.

Fundamentals of measurement. This chapter explains means of pressure,

temperature, liquid level, and fluid flow measurement.

Fundamentals of instruments. Recorders with strip and circular charts, different types of scales and inking pens, various drive mechanisms, controllers, motor valves, valve positioners, transmitters and receivers, and methods of by-passing and "zeroing" an instrument are covered briefly.

The safe way. The last chapter of the Basic Manual is devoted to personnel safety, equipment safety, and general fire protection.

One of the best ways to organize the program is to gather groups of six to eight about a table. Each departmental supervisor should teach his first-line supervisors in the same manner in which they will, in turn, teach their own men. Where possible, the men should be assigned at the outset to the first-line supervisors under whom they will be working. In this way, they work and study together and the supervisor builds the respect and authority he will need when actual operations commence.

At the beginning of the first session, a test, or "pre-training inventory" is given to the men. This pre-training inventory shows men who might think otherwise that there is much to learn. The same test is given at the completion of the course to indicate how much they have learned. It is important to maintain an atmosphere of informality during the testing; each man grades and keeps his own paper, and no written record of the scores is made.

Each trainee is then given a Study Guide, which contains detailed questions relative to the Basic Manual. The actual study may be conducted by silent or responsive reading followed by group discussion and recitation. The questions are answered in writing by each man.

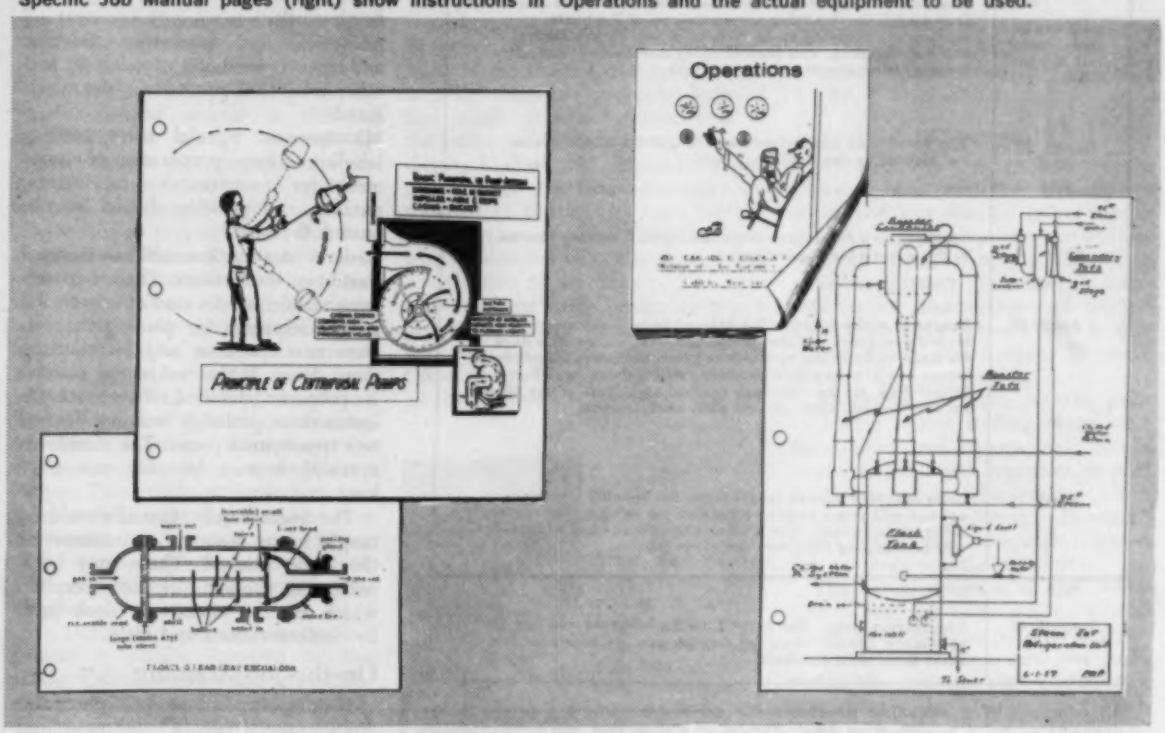
Any Basic Manual should be supplemented by models of pumps, valves, strainers, motor valves, and other pieces of equipment which may be used in the classrooms. The class work is mixed with field trips to nearby operating units to view some of the equipment in service. Whenever possible, experimental setups should be used.

This type of program can be covered in about one week, following which the new employees are ready to join experienced operators in the Specific Job Training.

Specific job training

The operation of a specific unit requires specialized training and information beyond the Basic Training Manual. Therefore, specific job instruction must be conducted to acquaint the operators with the details of their actual operating jobs. A Specific Job Manual is written for use during this phase of the training.

Typical pages from the Basic Training Manual (left) showing instruction on basic principles and types of equipment. The Specific Job Manual pages (right) show instructions in Operations and the actual equipment to be used.



Operation training

Continued

As in the case of the Basic Manual, it provides a permanent, written reference pertinent to the operators' duties.

Since the Specific Job Manual is written prior to any actual operation of the unit, much of the information is subject to early obsolescence. However, it is possible to direct the thinking of the operators and to suggest a probable course leading to efficient operation. An important by-product benefit of the Specific Job Manual is that in preparing it the technical supervision organizes and crystallizes its thinking and may use it as an effective check list while following construction work.

A sample Table of Contents of a Specific Job Manual is as follows:

Introduction. Acquaints the men with the manual, the plant, and the process. Defines the various operating jobs and tells of the raw material requirements. Discusses the nature and uses of the various products and by-products.

Outline of process. A brief description of each system in the unit, describing the major equipment and the critical operating conditions. A flow sheet of the entire process indicating all equipment and primary piping is also included.

Operations. Any process may be divided into various systems such as: a field storage system, unit tank area, reaction system, recovery system, compression system etc.; but topics such as centrifugal pumps and agitators, mechanical seals, and miscellaneous operating duties should also be covered in this section. The equipment in each system should be described in detail, from the type of vent system and gasket material to special shaft seals and safety valve settings. A complete instrumentation explanation should give the type of measurement, location, the normal operating condition, and the high and low alarm points of each instrument. Any special or complicated instrumentation system should be clearly sketched and defined.

This section also includes the complete startup and shutdown procedures and operating instructions for each system. Sometimes it is useful to have a summary of the normal operating conditions listed at the end of each system writeup for quick reference. Flow sheets and sketches are used wherever possible to make descriptions more readily understandable.

Utilities and utility failures. Flow sheets for power and utilities should show the distribution of the headers. Alarms, and instruction in the proper action to be taken immediately following a utility failure should also be thoroughly covered.

Automatic safety equipment. This section should indicate which motor valves open or close on air failure, explain emergency shutdown systems, signal alarm systems, and other safety equipment including interlocks, etc.

Safety. The section on safety is extremely important as a reminder of the Plant Safety Rules, special precautions for handling chemicals, precautions for maintenance men before entering equipment, personal protection, procedures for extinguishing fires, and the elimination of possible fire hazards.

Analytical and laboratory. Routine and special methods of analysis and other analytical procedures should be listed.

Maintenance. Special color coding, labeling of lines, preparation of equipment for maintenance, lubrication, gaskets, and packing should be discussed thoroughly.

General startup instructions—General shutdown instructions. These two sections should be devoted chiefly to the proper sequence for placing the systems into operation and for shutting them down. If the rest of the manual is properly detailed, these startup instructions probably will not exceed two typewritten pages. The shutdown instructions may be only one page long.

The Specific Job Manual should be taught in the same general manner as the Basic Manual. There may be a particular problem in the operation which can be effectively dealt with by demonstrations and films.

OPERATOR TRAINING SCHEDULE
For a Mid-April Start-Up

Week ending	Training
March 6 13 20 (half day in classroom-half day in field)	During these three weeks, the First Line Supervisors are taught from the Specific Job Manual by the Technical Staff. This will be a study of the entire new unit. In addition to studying the manual, they will be tracing flow diagrams, learning nomenclature of the basic equipment, studying scale models of unit (if available) and major piping, and familiarizing themselves with all the operating aspects of the new unit.
March 27	The First Line Supervisors are taught the Basic Training Manual by the Technical Staff.
April 3	Teaching new employees from the Basic Training Manual by the First Line Supervisors.
April 10	Teaching of the Specific Job Manual to both the experienced operators and the new employees. Allow two days for field study in the new unit to learn the overall equipment layout and primary flow patterns. Allow three days for acquainting all the men with general highlights of the Specific Job Manual. Give job and shift assignments.
April 17	Each operator will be taught from the Specific Job Manual and will dwell on his particular job assignment. Since there are normally four shifts, each First Line Supervisor will be teaching four men the same job.
April 18	The Startup Date. The First Line Supervisors and the operators assume their regular job assignments and start their shift schedule.

An example of a workable timetable for an overall training program in preparation for a hypothetical April startup of a new unit.

On-the-job training

If time, economy, and the particular circumstances permit, the new unit

can be started on water following the classroom study, field sessions, and assignment to shifts. This water run gives the operator the "feel" of instrument control and checks the operation of the instruments themselves. It provides a run-in period for equipment and an opportunity to check piping and gaskets for leaks without fire hazards. It provides a general cleanup of equipment and piping before startup. When the water is removed, the equipment is dried where necessary, and the actual process flows are started. This preliminary procedure will probably require about two weeks, depending upon the number of mechanical difficulties encountered.

It is desirable to have a periodic follow-up review to check the operators' retention of the information they have learned. This can be done in the form of either written or oral questioning; the latter is often more practical because of the demands on the operators' time during the early stages of operation of a new unit. Also, periodic rotation of operators from one job to another is desirable; the frequency with which this can be done will depend upon the particular circumstances involved, but it is generally considered that six months on one job is a minimum with one year being preferable.

Evaluation of training program

As previously stated, the results of such a training program are difficult to evaluate on a dollar basis. However, in one unit which was placed in operation over a year ago, there has not been one major spillage, serious operating error, or serious injury. A large share of the credit for this record is given to the operator training program described herein. #

Preparing for startup of a Unifiner-Platformer

ELTON P. BARNETT
Union Oil Company of California, Los Angeles, Calif.

In 1957 the Union Oil Companay of California successfully started up a new Unifining-Platforming Unit at its Los Angeles Refinery. This startup was somewhat unique in defining responsibilities among process licensor, design and construction contractor, Home Office group, and the refinery. A refinery-centered organization was used instead of one that was contractor-or Home Office-centered in order that the valuable knowledge and experience gained during the initial operations would be retained, to a maximum degree, within the normal refinery operating group. Shift foremen were given key assignments and a small core of specialists executed important functions throughout the design, construction, and startup stages. This article presents these organizational features, and such startup preparations as selection and training of personnel, inspection of equipment, and preparation of the operating instructions.

In Union, a major new construction project is usually handled by the Home Office Engineering and Construction group, and the refinery concerned, works with this group during the design and construction stages. However, it is the primary responsibility of the Home Office group to see that the units are properly designed and constructed, and turned over to the refinery in a ready-to-operate condition. The startup preparations discussed here are those necessary on the part of the refinery and, for the most part, are divorced from the problems associated with the design and construction of the units.

During the early design stages, a part-time refinery committee worked with the contractor and the Home Office group. This committee presented the refinery's viewpoint of the design and selection of equipment. Thus, the refinery's experience was incorporated at a time when changes could be made at minimum cost.

Elton Barnett defines the responsibilities in startup among the process licensor, design and construction contractor, home office, and refinery.

Selection of personnel

About two or three months prior to the start of construction, the refinery supervisor was selected to be responsible for the preparations, the startup, and the operation of the units. This man coordinated the refinery's interests during construction and worked closely with the Home Office Project Manager who was actually responsible for the construction.

About six or seven months prior to startup, plant staffing plans were formulated and contractual details were discussed with representatives of the labor union. The various labor-management problems associated with staffing the new unit required two to three months to resolve.

The actual selection of the operators to staff the units was completed about three months prior to startup. The selection of these men was made within the seniority and qualification provisions of the labor contract. Each

Continued

Unifiner-Platformer

Continued

applicant was given extensive interviews by one or more supervisors familiar with his previous experience and ability.

One of the most time-consuming jobs was the preparation of the operating manual. This project was begun about four or five months ahead of startup, most of the work being done by the startup engineers. All phases of the operation and equipment were presented, using numerous small drawings and sketches. Included were fire and safety precautions, design summaries, chemical reaction discussions, process descriptions, utility and auxiliary systems, startup and shutdown procedures, etc.

Inspection of equipment

An operating department representative inspected each item of equipment as soon as it was installed, including: reactor, tower and vessel internals; pump, turbine and compressor installation; instrumentation; electrical facilities; and process and utility piping. This was independent of the construction engineers' observations and was primarily made to check the condition of the equipment and to obtain conformance with refinery standards. In general the contractor did an excellent job with the details and the overall construction.

Training of personnel

The startup engineers and foremen were selected about six months prior to startup to participate in a gradual familiarization training program. Although busy on their normal assignments, they attended a weekly classroom training session of two to three hours conducted by the supervisor in charge of the startup. During this period each foreman and engineer visited the company's Oleum refinery in the San Francisco Bay area to observe a similar type of Unifiner-Platformer in operation. This on-the-job training proved valuable, since Oleum personnel freely discussed the lessons they had learned during two years of operation.

Four weeks prior to the continuous staffing of the units, a one-week review training program was conducted for startup foremen and engineers.

The next three weeks were devoted to full-time training of the operators by the startup foremen and engineers. The group was divided into four crews, each consisting of six operators, two engineers, ond one shift foreman who was in charge of the crew. These crews were kept together from the first day of training through the first two months of operation. When around-the-clock coverage began, each crew worked an extra shift every fourth week (equivalent to an average work week of 42 hours). This is called "four gang" scheduling. While the use of inact crews is desirable for the teamwork required in normal operation of units, it is an essential part of a good startup.

On the first day of training, each person was issued a copy of the operating manual. Each morning was spent in the classroom studying the manual. The afternoons were usually spent in the field reviewing the equipment studied that morning. Written and oral examinations were used, and each foreman was held responsible for determining that every operator in his crew was well qualified.

Organization

The successful initial operation of any big new unit requires the combined efforts of many people with various talents, and it takes good organization to minimize confusion. Figure 1 shows the organization used. The shaded positions represent the normal organization of the refinery operating department responsible for the continued operation. As the need for a given specialist disappeared, he was transferred from the organization. Previously, staff engineers had been placed in line positions directing the activities of the operations and the crews on shift. When the units were running smoothly, the engineers with their wealth of knowledge acquired during startup had returned to their normal jobs, leaving a comparatively green supervisory force.

The construction superintendent was thoroughly familiar with the unit and with the subcontractors who had furnished much of the equipment. Reporting to him was a small core of craftsmen and their supervisors, who remained on the job during the early stages of the operation. In the "debugging" of equipment, the construction superintendent's contributions proved to be very helpful.

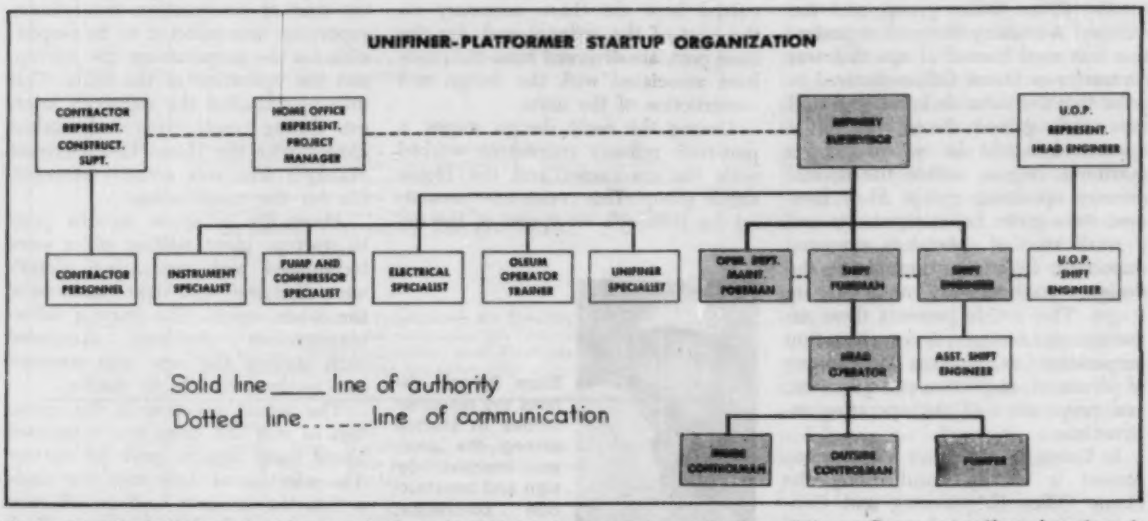


Figure 1. Shaded boxes in this organization chart show the normal organization of the refinery operating department. The other boxes designate the specialists used for startup and then transferred.

Classroom work is extensive in the period of training for the start-up job. (Photo courtesy of Dupont's employee magazine, Better Living.)

As the representative of the Home Office Engineering and Construction Group, the project manager, a chemical engineer, had worked on this project since its conception, and was the person most familiar with the details of the entire unit. He was largely responsible for the cooperation among refinery, Home Office, and contractors' personnel. He maintained a strict inspection of all equipment as it was installed and worked closely with contractors' and refinery personnel during the entire startup.

The process licensor (Universal Oil Products Company) sent four engineers (startup specialists) to assist with the startup and to evaluate the initial performance of the Platformer with regard to process and catalyst guarantees. These men helped establish key operating controls and made numerous worthwhile suggestions for improving the startup.

The instrument specialist with many years in a supervisory capacity in the refinery instrument department, worked part-time on this project during the early design. During construction he inspected all instrumentation facilities while being installed. As construction neared completion, it became a full-time job directing the checking, installation, and servicing of all instruments.

The pump and compressor specialist was a regular refinery machine shop foreman assigned full time when this equipment began arriving. He worked with contractors' personnel observing the installation of all pumps, turbines, motors, compressors, fans, etc., and made numerous corrections when it was easy and inexpensive to do so.

The electrical specialist was necessary because of the complexity of the electrical facilities. This specialist also worked part time during design and construction, and full time during startup.

The operator trainer assignment was filled by a head operator from the Oleum Unifiner-Platformer on loan to Los Angeles Refinery for six weeks. He assisted in classroom training and spent much time giving on-the-job training. He also assisted in analyzing operating and mechanical problems.

A Unifiner specialist from Union's Research Department supplied technical knowledge and startup assistance for the Unifiner. This specialist helped establish the necessary operating controls that optimized the pretreatment of the Platformer feed.

The assistant shift engineer assignment gave valuable operating experience to four young engineers, and provided assistance to the more senior shift engineers in handling technical problems, plotting data, writing operating procedures, making process calculations, etc.

Normal operator staffing is four per shift, but two extra operators per shift were provided during startup. All the operators had transferred from other departments within the refinery and their experience varied from two to 28 years. As a group, their ability was considerably above average and this contributed immeasurably to the smoothness of the startup and the ensuing operations.

The operating department maintenance foreman spends full time working on maintenance and mechanical problems. He is the liaison man between the operating and maintenance departments for routine repair and major turnaround work. This assignment reduces maintenance costs and off-stream time due to mechanical problems. During startup he worked almost full time at the Unifiner-Platformer.

The shift foreman was the senior line supervisor on duty and was directly responsible for the personnel and the overall operations of the units. The shift engineer was on staff assignment primarily as a technical advisor to the shift foreman. Actually, the two men on each shift worked together to combine the technical and organizational abilities of the engineer with the experience and work-directional abilities of the foreman. The four engineers had an average refinery experience of about eight years. After the units were operating satisfactorily, three engineers returned to their regular assignments and one remained as the staff engineer.

The four shift foremen who had progressed through the operator ranks to foreman had an average refinery experience of 24 years. The foremen played minor roles in previous startups, but during the early planning, the decision was made to place the foremen in charge of the operations from the beginning to assure that: the most capable men are in charge of the initial operation; there is no interim period when the units are supervised by inexperienced people; and the irreplaceable knowledge and experience gained during startup is retained in the refinery supervisory force. These same shift foremen still supervise the activities of the Unifiner-Platformer, although only part time.

Although the majority of the work lies in the preparations for startup, the big moment comes when the unit is put on the line for the first time. This is always an exciting climax to the months of preparation.

This startup was smooth and progressed ahead of schedule. The timetable had allowed several days for contingencies, but only about half the estimated time was required. As in any first operation, there were numerous problems, but none proved to be serious.

Both the Unifiner and the Platformer did an excellent job during the initial run of one year. The on-stream efficiency has been higher than anticipated and the performance of both units continues to be satisfactory. #

Anticipating maintenance problems in new plant startup

T. W. TOMKOWIT
E. I. du Pont de Nemours & Co., Inc., Chambers Works
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In planning a maintenance program for the startup of a new plant, one cannot adopt a conventional approach. Serious consideration must be given to such variables as the personnel available, the type of plant to be operated, its location, complexity, etc.

While the program discussed here was specifically developed for the startup of a new plant, any or all of the principles can be applied toward improving the maintenance effectiveness of an existing organization. The program was developed for a complex, continuous plant of refinery-type construction, novel to the plant site, posing many safety problems, and to be manned by short-service maintenance mechanics. The principal objectives of this program were a safe, economical startup, and the development of a self-perpetuating maintenance improvement program.

The anticipation of maintenance problems actually began when the plant was being designed. The program was according to the principles shown in the box.

maintenance principles

1. No amount of planning, preventive maintenance, training, etc., can be substituted for good supervision. The success of any maintenance effort, particularly at startup, depends on competent, aggressive, intelligent leadership. Potential foremen and supervisors must be evaluated in terms of their ability to cope with the personality of the plant.
2. Observation is as effective and important as preventive maintenance. Many problems can be anticipated by recognizing the obvious.
3. A successful Maintenance organization must be familiar with the process and its limitations, and, conversely, Operations must be familiar with the equipment and its limitations. Maintenance engineers must analyze problems from a process point of view if final solutions are to be developed.

Design analysis

A task force was established to analyze equipment design and layout from an engineering viewpoint, and to anticipate maintenance problems, operability, and conformity to local plant engineering practices.

Area filing system

When construction was started, a clerk was assigned to the area to set up an accurate, up-to-date equipment file. As the first step of this program, we developed a file folder on which we could record pertinent information. This represents the most important facet of the startup program, since the quality of all the work that followed depended on the accuracy and completeness of the information obtained from the area file.

Spare parts and extra machinery

In reviewing design special emphasis was directed toward equipment standardization. Spare parts requirements were based on an analysis of vendors' lists in the light of anticipated service and pilot plant experience. Spare parts requirements were ultimately based on the analysis and the execution of a Replacement Parts Agreement, a program developed by Dupont. The agreement established the price and availability of certain parts at the manufacturer's warehouse.

Selection of personnel

Foremen were selected from available wage-roll foremen after an interview and were assigned to the plant approximately six months before startup. All members of supervision participated in the development of all maintenance programs and training of wage-roll personnel.

Mechanics were selected from available short-service men recommended by foremen because of their aggressiveness, unusual job interest, and above-average mechanical ability.

T. M. Tomkowit discusses the necessity for anticipating future maintenance problems with a well-planned program.

Representative work control sheets used at various stages of startup to anticipate future maintenance problems.

Training

1. Foremen. The foremen were exposed to two training programs. The first was concerned with leadership and the second with Engineering Department administrative problems. The leadership program was most important since the foreman ultimately developed and conducted the mechanics and operations training programs.

2. Mechanics. The mechanics were assigned to the plant approximately six weeks before startup. All mechanics were taught the basic principles of pump and mechanical seal maintenance and specific problems peculiar to the plant. At the conclusion of the program, each mechanic was assigned a booklet containing pertinent maintenance information.

3. Operations. A maintenance appreciation program was developed for operating personnel. Equipment and maintenance problems were discussed from an operating point-of-view to acquaint personnel with the way equipment functioned, how it should be operated to minimize maintenance problems, how to recognize simple difficulties, and the corrective measures that should be taken.

Equipment check out

Pilot plant experience indicated that we might expect problems with our pump and seal systems. To avoid assembly problems, a check sheet was developed and completed by plant personnel which indicated the quality of assembly. As a result of this program, it was possible to start up all

SPARE PARTS ANALYSIS SHEET

BPF NO. 134681 E.P NO 1074-418-47, 73, 129 E M 418-47 10

STOCK NO	NO/EQ PC	DESCRIPTION	MATERIAL	VENDOR MINIMUM	STOCK MAX	STOCK MIN
J-70-I-158	1	Bearing Housing # 4	C.I.	1	0	0
J-70-I-159	1	Outboard Bearing Cover	C.I.	1	0	0
J-70-II-70	1	Bearing Adaptor Locknut	Steel	1	1	1
J-70-16-9	1	Outboard Bearing Adaptor	Ni-R	1	1	1
J-70-4-20	1	Inboard Bearing	Steel	0	1	1
J-70-4-80	1	Outboard Bearing	Steel	0	1	1

Equipment Pc Description: Duriron WHK 4 Cent Pump
Original Order No.: PAC 5772 1/2
Original Vendor: Duriron

Consider: Delivery - Weeks
Unit Cost
Estimated Life in Months

PUMP CLEARANCES & RUN-OUT TOLERANCES

For Pumps P1-P2, Model SHB2

	DESCRIPTION	DIMENSION
1.	Throttle bushing clearance	0.006" - 0.010"
2.	Shaft end play	0.001" TIR*
3.	Shaft radial play	
	(a) Coupling end	0.002" TIR*
	(b) Inboard end	0.002" TIR*
4.	Shaft run out at stuffing box	0.004" TIR*
5.	Diametral wear ring clearance	0.010" - 0.030"
6.	Impeller front clearance	0.025"
7.	Coupling face to face	4"
8.	Seal perpendicular to shaft	0.0005" maximum

MAINTENANCE PROCEDURE

EQUIPMENT NAME:
Column Feed Pump

EQUIPMENT DESCRIPTION:
BPF 134681, Duriron SHB 2-070, BPF 134809, Crane Seal 9V-SET 21F-QR191, Motor 2 HP at 1730 RPM

FUNCTION:
Pumps filtered crude solution from the storage tank, T-22, to column, CL-21

HAZARDS:
a. Fire and explosion hazard
b. Skin and eye irritant
c. Toxic

SAFETY EQUIPMENT:
Air Mask - full face
Rubber gloves
Non-sparking tools

MANPOWER REQUIREMENTS:

WORK REQUISITION

BP 7502

EQUIP NO. _____ SHUTDOWN REQ. _____ NO. _____
BLDG. NO. _____ EMERGENCY _____ ELECTRICAL _____
CODE _____ ROUTINE _____ INSTRUMENTATION _____
DATE _____ WEEKEND _____ AREA MECH. _____
REQUESTED BY _____ SHUTDOWN _____ E.S. APPROVAL _____
_____ APPROVED BY _____ _____
CHEMICAL HAZARD _____
CONDITION OF EQUIP _____ ESTIMATED HRS. _____

PROVIDE SKETCH AND DESCRIPTION:

W.O. No. I.& ☐ G.L.E. ☐ P.D.E. ☐ P.P. ☐ P.S. ☐ A.E. ☐

Maintenance problems

continued

pumps without a single failure. Similar check sheets were prepared for compressors, turbines, and other critical pieces of equipment. They were also used for less glamorous tasks—accounting for blanks, etc., during equipment testing and clean out.

Anticipated maintenance program

1. Preventive Maintenance Schedule. Every piece of equipment was listed and analyzed for anticipated maintenance problems. A schedule was developed which listed the necessity for a shutdown, frequency, and manpower requirements for all repetitive jobs.

2. Maintenance procedures. Maintenance procedures were developed for all complex, hazardous, or precise maintenance jobs indicating safety, material, tools, and the exact method to be used for the repair and replacement of the indicated piece of equipment. The procedures were created to have a record of the proper job method and were used for retraining mechanics and for training new people in proper maintenance techniques. No attempt was made to develop a procedure for every maintenance job.

Tool and Material lists were developed for all repetitive jobs.

3. Job analysis. Methods engineers were assigned to analyze all repetitive work. Job sheets were developed to indicate sequence, elapsed and shutdown time, and manpower requirements. A similar maintenance program was developed for electrical and instrumentation work. The same pattern and techniques were used in preparing for startup and planning for routine maintenance work.

Planning routine maintenance

1. Shift report. The shift foremen were expected to survey the plant and establish the condition of each piece of equipment. To anticipate maintenance problems during startup, a check sheet was developed listing every piece of equipment. This form served as a diary and record of the progress of mechanical problems.

2. Work requisitions. A standard requisition (page 45) was developed and used for all maintenance work. It was particularly useful in coordinating the efforts of contributing crafts. It was numbered to facilitate control and scheduling.

Planning and scheduling

To increase the effectiveness of maintenance personnel, a methods engineer was established as a plant scheduler. All work performed in the area was executed on a planned, scheduled, preanalyzed basis. The methods engineer established a 24-hour schedule of work after discussion with maintenance and operating personnel.

To guarantee continuity of operation, periodic plant shutdowns were scheduled. At this time, all major preventive maintenance work and deferred maintenance was to be executed. To reduce the burden of continually rewriting and checking on job schedules, a list of about 700 repetitive jobs was recorded on master cards using IBM equipment. When a shutdown was planned, a preliminary list of work was printed and distributed to all interested parties. Additional jobs, generally of a one-time nature, were added. Priorities, deletions, and sequence were then agreed upon between Operations and Engineering. The jobs were then preanalyzed by a methods engineer and a 24-hour schedule of work was printed listing job elements arranged in sequence, manpower requirements, and elapsed time.

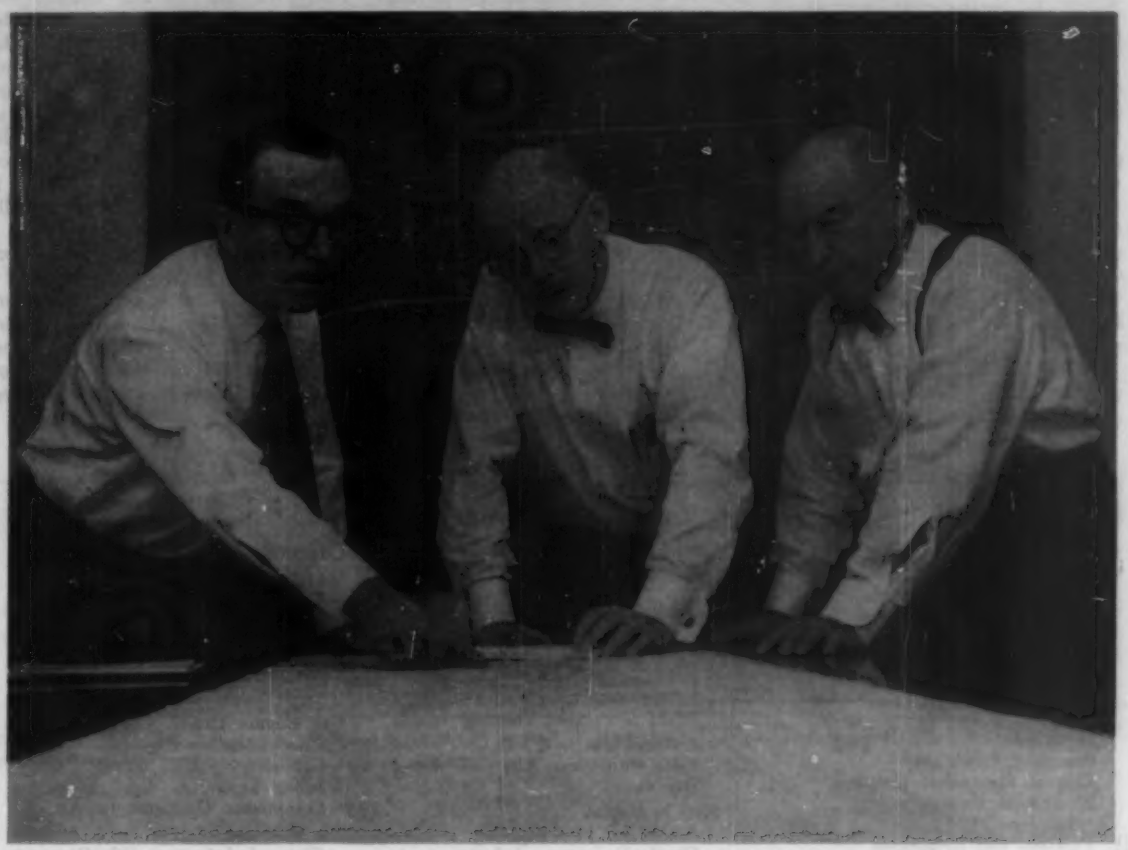
A system has been established whereby each problem is reviewed from an operating point of view, and a mechanism for making the program self-perpetuating has been established. Modifications to equipment and to operating procedures have been made, and, as a result, many problems have been eliminated. Difficulties are also being reviewed to establish design inadequacies, and corrections are being made to avoid recurrence.

In summary, there is little difference in planning a startup program and administering an existing maintenance organization. The principles of personnel selection, training, spare parts analysis, and preventive maintenance are applicable to both situations. Plant site, personnel available, and the complexity of the plant to be operated or started, should determine the type of program developed.#

CHECK SHEET

PUMP & SEAL INSPECTION REPORT

INDICATE	Measurements and Tolerances Inspector Date
GENERAL	Identify Equipment
PRELIMINARY INSPECTON	Base Plate and Anchor Bolts Piping Alignment
MOTOR	Coupling Run Out - O.D. and Face Rotation
PUMP	Packing Code Coupling Run Out - O.D. and Face Shaft Run Out - End Play - Radial Play Bearing Lubrication
SEAL	Throttle Bushing – Diameter, Clearance Seal Gasket – Code and Thickness Stationary Face - Shaft Clearance - Run Out
IMPELLER	Diameter - Clearance – Face and Back Casing Gasket Code - Thickness Shaft Alignment
MISCELLANEOUS	Guards Placed Seal Flush System Complete and Functioning



Weeks, Eames, and Sturgis (l. to r.), study the design layout of a client's plant.

The contractor's role in plant startup

J. P. EAMES, N. H. STURGIS AND C. F. WEEKS
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THE contractor's overall job in plant startup is to provide not only a physical plant, but also information and other assistance which will help the owner put the new plant in operation with minimum delay and at minimum cost. He provides a unique integration of specialized engineering services which only few large chemical companies can afford, or find worth maintaining. His role in the plant startup begins the day he starts the plant design.

Previous literature

A search of the technical literature has revealed only three previous publications devoted to chemical or petroleum plant startup procedures *(1, 2, 3)*. These emphasize the value of simulated operations, show that preparation for startup begins with plant design, and discuss the value of the operating manual in plant startups. The power plant field is covered by the recent articles of Hunnicutt *(4)*. Totten's *(5)* description of simulated operations and the meticulous cleaning employed in starting up the Army's Portable Power Reactor at Fort Belvoir is also of value.

continued

Contractor's role

continued

Startup considerations in plant design

It is frequently advisable to avoid making the parts of the plant too interdependent since the apparent savings might well be offset by a more prolonged startup. Features which will facilitate the startup should be incorporated early in the design. These include selection of types (or even makes) of equipment familiar to the Owner's organization, instrumentation, winterizing details, and special lines for startup purposes and product rerunning.

In laying out the plant, compactness is desirable but it must be consistent with safety, ease of operation, and maintenance. A recently completed ethylene plant, having both compactness and accessibility, is shown in Figure 1.

The operating manual. The Operating Manual is one of the most important packages of information supplied the Owner by the Contractor. A well-written, comprehensive manual, available well in advance of the plant completion, enables the Owner's technical personnel to become familiar with the process and to start operator training early. It should contain:

1. Basis of design
2. Detailed description of process
3. Description of utilities
4. Process equipment
5. Preparation for initial operations
6. Startup procedure
7. Shutdown procedures
8. Rerunning
9. Safety

Field testing and inspection instructions. The Field Testing and Inspection Instructions manual is prepared by engineers in the Contractor's home office for use by the construction group. It includes the details of the procedures to be used, and lists the design, test pressure, and test medium for each line and piece of equipment. By having this careful compilation of information readily available in the field, the equipment is properly tested without loss of time and the Owner is assured that the plant is mechanically sound.

The mechanical catalog. The contractor frequently supplies copies of a Mechanical Catalog as a supplement to the Operating Manual. This generally includes specifications, drawings, the field testing and inspection instructions, and manufacturers' literature.

Preoperational Check List

General plant check

- Piping Completion
- Safety Valve Setting
- Piping Expansion and Support
- Operability
- Accessibility
- Winterizing Details
- Cleanliness of Critical Piping
- Sampling Provisions
- Critical Equipment Details
- Equipment Expansion
- Insulation
- Packings and Lubricants

Pressure testing and cleaning

- Pressure Test Equipment
- Pressure Test Piping
- Clean Equipment
- Clean Piping
- Drain Water to Prevent Freezing
- Sectional Continuity Testing with Air

Commissioning of utilities

- Electric Power and Lighting
  - General Check
  - Isolation and Safety
- Service Air
  - Clean by Air Blowing
  - Keep Water Drained
- Underground Drainage
  - Cleanliness
  - Seals Established
  - Free Flow
  - Tightness
- Steam
  - Blow Main Headers
  - Blow Laterals
  - Instruments
- Condensate
  - Disposal to Drains
  - Traps

Commissioning of Utilities (cont'd)

- Cooling Water
  - Flush Inlet Headers
  - Flush Laterals
  - Flush Return Lines
  - Instruments
  - Drain to Prevent Freezing
- Instrument Air
  - Blow with Clean Air
  - Dry Out
- Fire Protection
  - Access for Fire Fighting
  - Check Underground Lines
  - Freezing Protection
  - Flush Lines
  - Check Equipment
  - Personnel Safety Provisions
- Inert Gas
  - Identify and Provide Warnings
  - Air Blow
  - Isolate and Purge
- Fuel Oil
  - Identify and Provide Warnings
  - Air Blow
  - Isolate and Purge
- Fuel Gas
  - Identify and Provide Warnings
  - Air Blow
  - Isolate and Purge

Commissioning of equipment

- Temporary Strainer Installation
- Fired Heaters
  - Instruments and Controls
  - Dry Out Refractory
- Check for Piping Strains on Equipment
- Electric Motors
  - Rotation
  - Drying Out
  - No Load Tests
- Steam Turbines

Commissioning of equipment (cont'd)

- Check Auxiliary Lubrication and Cooling Systems
- Instruments
- No Load Tests
- Light Load Tests
- Gas Engine Driven Compressors
  - Check Auxiliaries
  - Instruments
  - Idling Tests
  - Compressor Operation on Air
- Gas Turbines
  - Clean Lubricating Oil Governor and Seal Systems
  - Instrumentation and Speed Control
  - Auxiliary Heat Recovery System
- Centrifugal Compressors
  - Clean Lubricating and Seal Oil Systems
  - Instrumentation and Controls
  - Preliminary Operation of Lubricating and Seal Oil Systems
- Vacuum Equipment
- Pumps
- Moving Machinery Hot Alignment Checks

Final preparations

- Installation of Orifice Plates
- Vacuum Testing
- General Continuity Testing
- Drying Out Systems
  - Process
  - Refrigeration
- Simulated Operations
- Charging Auxiliary Chemicals (e.g., Caustic)
- Charging Special Treating Agents (e.g., Catalysts)
- Purging

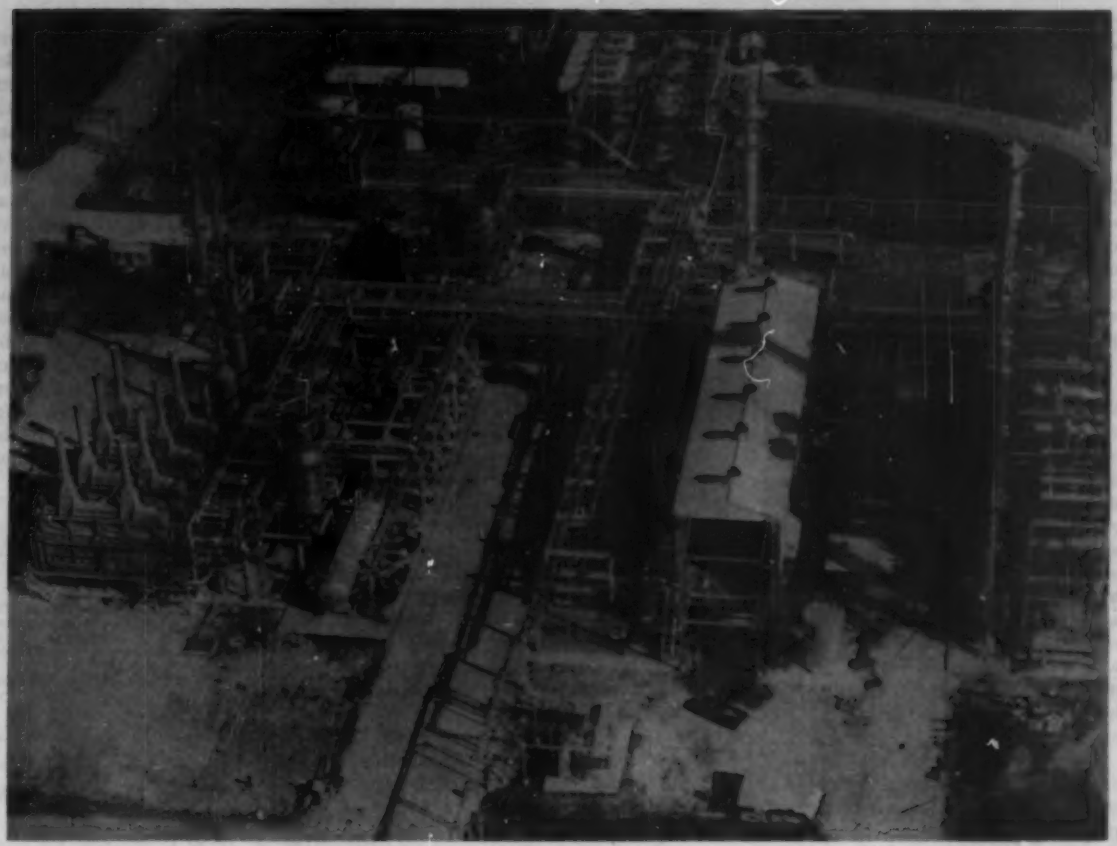

Figure 1. Jefferson Chemical's Ethylene Plant No. 2 at Port Neches, Texas, is a typical Stone & Webster designed ethylene plant having both compactness and accessibility.

Contractor's operating team

With the Operating Manual, Mechanical Catalog and home office engineering completed, focus on the plant startup moves to the job site. Here, the Contractor's field forces are joined by the operating team. The make-up and number of this group depend on how much of the preoperational preparations are to be performed by the Owner and how much assistance he requires during the initial operations.

The nucleus of the team should usually consist of operations specialists and a process design engineer who knows his way around operations and is familiar with the characteristics of the particular process. This team should be supplemented, as required, by mechanical and instrument specialists.

Owner-contractor conference on respective responsibilities. Owner and Contractor representatives should confer and define the responsibilities of both parties not only in the preoperational work, but also in the operations which will follow. Some of the duties of the Contractor's representatives will have been established in the contract and by correspondence. The others must be decided without delay and clearly spelled out for all. Only in this manner can it be made certain that some tasks will not be overlooked and, that misunderstandings will be avoided. Recommended divisions of these responsibilities are discussed later.

Conferences with various owner groups. It is the duty of the Contractor's operating team to continue the flow of information about the new plant to the Client. A series of conferences should therefore be arranged with the Client's technical personnel shortly after the Contractor's operators arrive at the plant site. Conferences should be held with the Client's groups responsible for operations and technical service, laboratory facilities, maintenance, and safety. Any unusual hazards must be brought to the Client's attention and the procedures for coping with these hazards fully understood. All this information must then be passed along by the Client's technical personnel in clear and simple form to the nontechnical men.

Contractor's preoperational activities

The Contractor's operating team goes over the entire unit in close cooperation with the construction forces. No process or mechanical detail is left unchecked. Even though the construction group has exercised constant, careful supervision, all this effort by the Contractor's operations team is necessary. This thoroughness and care reduce startup effort to a surprising degree.

The Contractor is responsible for making certain that the mechanical equipment is in proper working order and alignment and that it has been pressure tested. He is also responsible for cleaning out and hydrostatically testing vessels, tanks, and piping.

Instrument calibration should be a joint effort, with the Contractor having

continued

Contractor's role

continued

the prime responsibility. The advantage of this procedure to the Owner is that his instrument personnel thereby become familiar with the instrument locations and their operation. Even more imporant, there is mutual satisfaction that the calibrations are correct, thus avoiding any misgivings if questions arise later on operations and yields.

Other phases of the work, such as chemical cleaning, drying out, continuity testing of the systems, and circulation of fluids are best handled by the Owner. This division of responsibility costs the Owner less since overtime pay to construction labor is minimized. It also gves the plant operators excellent training. The Contractor's construction forces would be available to render assistance if needed, and his operating group would function in an advisory capacity. The division of effort outlined is, by no means, hard and fast; it is, however, considered the preferable one.

Preoperations check list. Well in advance of the busy period just prior to the startup date, it is advisable to prepare a preoperations check list of the important items which must be taken care of before feed is charged to the unit. The list is not meant to be a substitute for thinking; it serves as an automatic reminder and gives the operator more time to think. If the paper work does not become too time consuming, the check list can be supplemented by target dates and, later, accomplishment dates. Properly prepared, such a list is a valuable aid to the preoperational progress.

Continuity testing and simulated operation. The preoperational steps, continuity testing, and simulated operation which are included in the check list, are considered of special value. In the continuity test, safe working pressures are applied, and air, inert gas, or water passed through the lines and equipment, or retained in them. Soap tests should be applied to the joints which could not be tested previously. In this manner, it is demonstrated that the plant is tight where is should be and free where it should be.

It is logical at this point to progress directly, if feasible, to simulated operation. A considerable amount of equipment and line cleaning can be accomplished in this manner. Numerous instruments can be put in operation, although final selection of set points must frequently be deferred. Excellent operator training is afforded by this procedure.

A second stage of simulated operation that is sometimes very effective involves the use of materials similar in composition to those which will actually be processed. Frequently, synthetic mixtures can be prepared, fractionated, and recycled. Much of the equipment can be placed on nearly final conditions before feed is charged and the problems of startup confined to a relatively small part of the plant.

Startup

The last phase of the Contractor's work at the job site is the participation of his operating team in the startup. This scope of duties should be set by the conference on Owner and Contractor responsibilities referred to previously. It is generally preferable that the Contractor's personnel serve in an advisory capacity. They would participate in the actual operating only in case of emergencies and would dictate operating conditions only when making acceptance tests.

The Contractor's operating group can offer considerable help in selecting the initial operating conditions. This is true if the startup is to be with a feed stock somewhat different from that for which the plant was designed. After feed has been introduced, the Contractor's men provide extra overall surveillance of the plant since they are well versed in operations and are thoroughly familiar with the process. Since they are acting as advisors and, therefore, do not have supervisory responsibilities, the Contractor's representatives can devote the necessary time to the analysis and solution of any special problems that may arise. The Contractor's men, by drawing on their extensive experience and the design knowledge of the particular plant, can offer many suggestions which will help bring the plant to full production in the minimum time.

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3. Browne, R. Y. and C. C. Brewer, *Ind. & Eng. Chem.*, *48*, No. 1, 68A (1956)
4. Hunnicutt, J. H., *Power Engineering*, *60*, No. 12, 102 (1956); *61*, No. 1, 70; No. 2, 84; No. 4, 88; No. 5, 68; No. 8, 67; No. 10, 95 (1957)
5. Totten, J. M., *Power Engineering*, *62*, No. 4, 50 (1958)

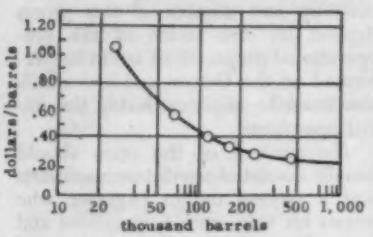
CORRECTION

In the article "Shale Oil . . . How Soon?" by Fred L. Hartley, which appeared in the March, 1959, CEP, two errors occurred.

On page 63, column 3, paragraph 2, the sentence, "Because the study which I have mentioned above, performed by the National Planning Association, reflects areas of interest, etc. . ." was misleading since the study had not been mentioned previously. Readers who wish to refer to the complete report will find it listed on page 64 of the same issue as reference No. 1 in Literature Cited.

On page 62, column 3, line 18, the sentence "Some tariffs would be required in the first year to return 7 percent on the investment allowed a common carrier pipeline under the Elkins Act Consent Decree.", is open to a misunderstanding of the word "tariffs". By "tariffs," Mr. Hartley meant "prices", and this sentence referred originally to a deleted figure printed here. The word "tariff" had no relation to any Governmental act or decree.

With reference to the figure



(above), the sentence should have read, "Tariffs shown would be required in the first year to return 7 percent on the investment allowed a common carrier pipeline under the Elkins Act Consent Decree."

Fuel cells

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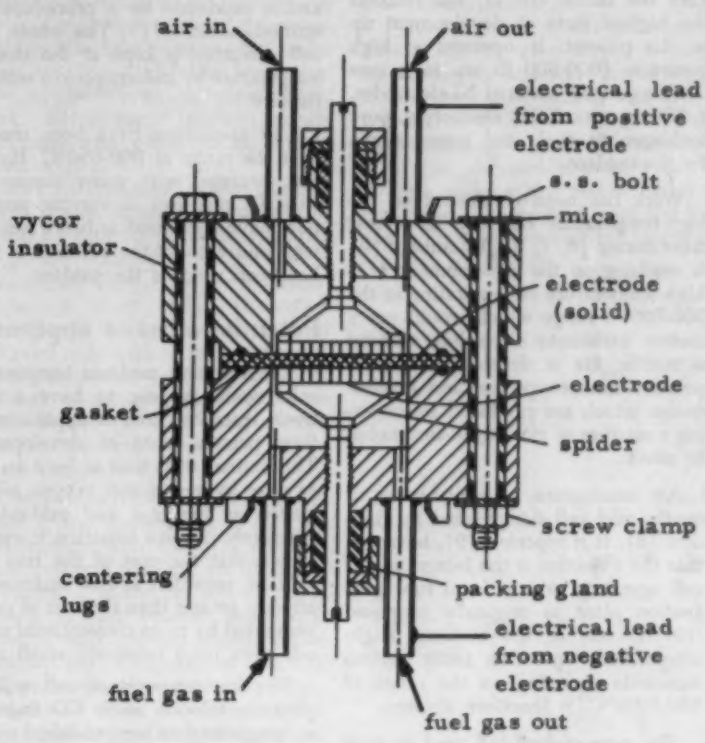

Figure 1. Cross-sectional view of the type of fuel cell used throughout this work.

Application of the high temperature fuel cell to the generation of electric power from fossil fuels—its potential, efficiency, and limiting factors. Experimental and theoretical work is analyzed.

THE FUEL CELL is an old concept and research work on this subject has been in progress on a limited scale for approximately 100 years. A fuel cell may be defined broadly as an electrochemical device for the continuous conversion of a portion of the free-energy change in a chemical reaction into electrical energy. It is distinguished from a battery in that it operates with continuous replenishment of the fuel and the oxidant at the active electrode areas and thus does not require recharging. This article will be limited to cells which effect the electrochemical combustion of a fuel gas with air or oxygen and to their use with a primary carbonaceous fuel from which the fuel gas is generated.

The fuel gas is supplied to the negative electrode and the oxidant to the positive electrode. The two electrodes are electrochemically connected through an electrolyte which prevents mixing of the fuel gases and the oxidant and provides an electronically insulating and electrolytically conducting linkage between the two electrodes.

Many excellent reviews *(1)* have been published in recent years in the fuel cell field. We will, therefore, concern ourselves principally with the more recent developments. Three types of fuel cells, within this narrow definition, have been under investigation, distinguished largely by the temperature range within which they operate. They are the low-temperature cells which operate approximately in the range from room temperature to about 100°C., the medium-temperature cell which operates in the range of about 150-250°C., and the high-temperature cell which operates in the range of 500-1000°C.

Considerable success has been obtained in research and development work on the low- and medium-temperature cells in recent years *(2, 3,*

Continued

NEW POTENTIALS

Fuel cells

Continued

4). In the medium-temperature category the Bacon cell (5) has reached the highest state of development up to the present. It operates at high pressures (600-800 lb./sq. in.), uses double-porosity sintered Ni electrodes, a 27% aqueous KOH electrolyte, pure hydrogen as fuel, and pure oxygen for the oxidant.

Work has been conducted on the high-temperature fuel cell in several laboratories (6, 7, 8). Chambers (9) is working on the development of a high-temperature cell operating in the 500-700°C range which would use a molten carbonate electrolyte without a matrix. He is developing double-porosity cermet-type fuel and air electrodes which are produced by sintering a mixture of zinc oxide and metallic silver.

No information is available to us on the fuel cell design used by Randles (8). It is reported (9), however, that the objective is the integration of cell operation with a fossil fuel gasification plant as originally proposed (10) by one of the authors. High-temperature operation using carbon monoxide as a fuel in the range of 800-1000°C. is therefore stressed.

The type of fuel cell used in most of our work is illustrated in Figure 1. Several modifications have been made over the original design shown but the basic layout is essentially the same. It consists of two porous electrodes pressed against a disk-shaped "solid" electrolyte. The electrolyte used in most of our investigations has been mixed alkali carbonates, using an equimolar mixture of lithium and sodium carbonates impregnated upon a porous magnesia matrix. Typically, a matrix of 28% porosity is employed. The magnesia must be of a high grade and is produced by a procedure described earlier (11). The whole fuel cell assembly is kept at the desired temperature by immersion in a suitable furnace.

Cell operations have been studied over the range of 600-850°C. Hydrogen saturated with water vapor, and CO-CO_2 mixtures in varying proportion, have been used as fuel gases. Air with and without the addition of CO_2 has been used as the oxidant.

Potential areas of application

The low and medium temperature cells would appear to have a relatively restricted area of application at their present state of development. This statement is true at least as long as pure hydrogen and oxygen are required as fuel gas and oxidant, respectively. In this situation it can be shown that the cost of the fuel plus oxidant, regarded as raw materials, is already greater than the cost of power generated by more conventional methods even on a relatively small scale.

The low-temperature cell will apparently tolerate some CO impurity, although no data are published on this point. A high partial pressure of oxygen is required at the positive electrode for high power output.

It is clear that utilization of relatively impure gases such as producer gas or water gas, the use of air rather than oxygen and atmospheric-pressure operation would be required before the low-temperature cell could become interesting as a basic power source.

The high temperature fuel cell has a much larger potential area of application for two reasons: (1) it can accommodate relatively cheap fuel gases containing CO, and (2) higher over-all electrical efficiency can be achieved from the original fossil fuel such as coal or natural gas. This can be achieved (10) by integration of the cell operation with the process wherein the fuel gas is generated from the original fuel, *i.e.*, reforming of CH_4 to CO-H_2 mixtures or coal gasification at an overall thermal efficiency of 70-75%.

The high-temperature cell can thus potentially be used as a primary power source competitive on an economic basis with more conventional methods. Its main advantage would then reside in the higher efficiency (up to 75%) with which power can be generated. The cell offers the most potential where low voltage d.c. power is required, such as in electrochemical or electrometallurgical applications.

Some important factors which determine the economics are: the cell life, cost of fabrication of the cell elements, over-all electrical efficiency, and power output/unit of cell area that can be achieved. The cell life that can ultimately be achieved is not too well defined at present. The cost of the cell elements is also difficult to establish since materials will be required which are not articles of commerce at present.

It is the purpose of this article to discuss the last two items in the light of our present data and knowledge

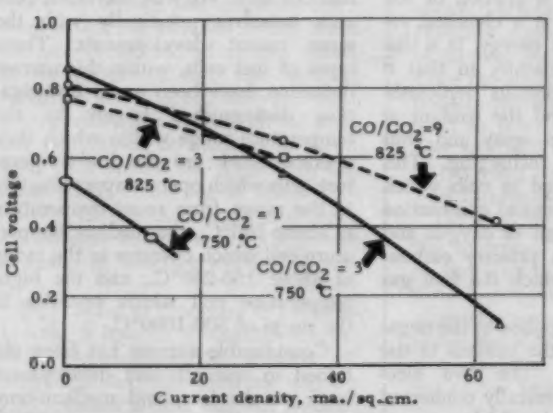

Figure 2. Cell operation with nickel electrode and CO-CO_2 fuel gas.

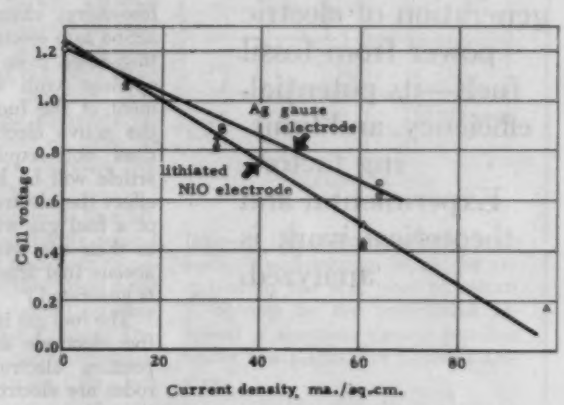

Figure 3. Cell operation with H_2 fuel gas at 700°C.

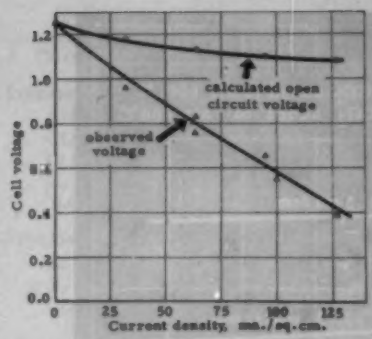

Figure 4. Cell operation with H_2 fuel gas at 750°C.

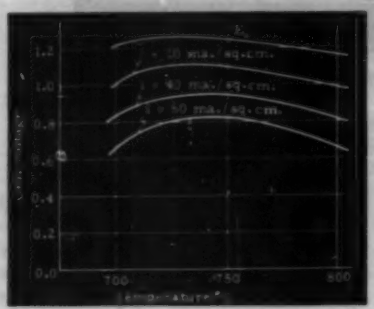

Figure 5. Effect of temperature on cell performance.

of the cell operation and gasification processes. The factors which limit the ultimate achievable performance are discussed in the light of our understanding of the mechanism of the cell action.

Experimental results

Various air electrodes have been tested, including porous micrometallic 316 stainless steel and nickel. These and other metals do not show sufficient corrosion resistance for practical application. A sintered nickel oxide air electrode has been used with considerable success. The nickel oxide is made semiconducting by the addition of 1 to 2% lithium. Excellent results have also been obtained with the silver-gauze-type electrode, used directly, and without the silver powder, used by Ketelaar *(6)* and Broers (7). Both the nickel oxide and silver-gauze electrodes appear to be completely corrosion resistant and both operate in air without electrode polarization (at least at current densities up to 100 amp./sq. ft.). This confirms the results reported by Broers (7).

Porous nickel, nickel gauze, porous stainless steel alone and activated with iron-iron oxide mixtures, lithiated manganous oxide (lithiated to render the manganese semiconducting), and silver gauze have been used as fuel electrodes, and all, with the exception of stainless steel alone, gave good open-circuit voltages with hydrogen as the fuel gas. Porous nickel gave consistently the best performance under these conditions and has been used most extensively in our experimental work. Silver gauze showed poorer performance as a fuel electrode compared with nickel.

The performance with CO-CO_2 mixtures was, in general, considerably poorer. Within the principal operating range of 700-850°C, the theoretical open-circuit voltage for an equimolar mixture is about 1.0 v. Theoretical open-circuit voltage has so far been achieved only with an iron-oxide activated electrode, but it was found difficult to achieve reproducible results. Broers (7) had good success with an iron-oxide activated silver-gauze electrode.

Porous micrometallic nickel and nickel gauze were found to give fair performance with CO-CO_2 mixtures. Some performance data are illustrated in Figure 2 where the cell voltage is plotted against current density (a factor of 0.93 converts ma./sq. cm. to amp./sq. ft.). Temperature and CO/CO_2 ratio are shown as parameters. In this case silver gauze was used as the air electrode. Ten percent by volume CO_2 was added to the air stream.

Note that in all cases the open-circuit voltage is below the theoretical value, particularly at the lower CO/CO_2 ratios. The curves all bend concavely downward indicating electrode polarization. Polarization is also indicated by the fact that the observed voltage drop on current drain is generally greater than calculated from cell internal resistance, as measured by an a.c. bridge. Similar performance data with water-saturated hydrogen are shown in Figures 3 and 4. CO_2 was added to the air stream in all cases and porous nickel was used as the fuel electrode throughout.

The relationship between voltage drop and current drain was assumed to be linear (Figure 3), and the best straight line was drawn by least-squares analysis. The slope of the line is just equal to that calculated from the measured internal resistance in the case of the nickel oxide electrode. It is greater by a factor of 1.8 for the silver-gauze electrode. The latter indicates some polarization is in effect, but in spite of this, the silver-gauze electrode system shows a lower effective internal resistance. This is attributed to a high contact resistance between the nickel oxide electrode and the metal conductor. Double-porosity nickel oxide electrodes are now under development in our laboratories which show promise of significantly reducing this contact resistance.

Figure 4 gives the cell-performance data at 750°C. using the silver-gauze air electrode. Relatively high-current drains were used in this run and it was therefore desirable to correct the open-circuit voltage for the depletion of oxygen and carbon dioxide on the air side and for the accumulation of water and carbon dioxide on the fuel gas side. The two half-cell reactions may be written as

$$2e + \tfrac{1}{2}O_2 + CO_2 = CO_3^{=} \qquad (1)$$

$$CO_3^{=} + H_2 = H_2O + CO_2 + 2e \qquad (2)$$

The open-circuit voltage may then be calculated by use of the Nernst equation

$$E = E_o + \frac{RT}{2F} \ln\left(\frac{p_{O_2}^{1/2}\, p_{CO_2}\, p_{H_2}}{p_{H_2O}\, p_{CO_2}}\right) \qquad (3)$$

The curve for the observed voltage was drawn by making use of the corrected open-circuit voltage shown, plus a least-squares analysis of the data points based on an assumed linear potential drop with current drain. Note that the actual curvature of the observed voltage curve is completely explained on the basis of the change in open-circuit voltage due to changes in gas composition as a result of current drain.

The observed voltage drop was found to be, within the limit of experimental error, equal to the predicted IR drop from the measured internal resistance. Thus, it can be concluded that the silver-gauze air electrode and the porous nickel hydrogen electrode operate at 750°C. without polarization, at least at current densities up to 125 ma./sq. cm. (116 amp./sq. ft.)

In view of the good performance obtained with hydrogen, it may not be necessary to develop a polarization

Continued

Fuel cells

Continued

free CO electrode. All fuel gases from natural fuels would contain considerable quantities of hydrogen. The CO could be burned in the cell as hydrogen if the water gas shift reaction occurs spontaneously in the cell.

Figure 5 shows the effect of temperature on cell performance with the same electrode system. Note that both the open-circuit voltage and the voltage with current drain go through a maximum at about 750°C. This behavior is understandable since the cell operates with some polarization at temperatures below 750°C. The thermodynamic open-circuit voltage, as is well known, falls slowly with increasing temperature for the hydrogen-oxygen system. The decrease in voltage under current drain may be somewhat sharper in this series than would normally be true. It was observed that the internal resistance of this cell showed a substantial increase at 800°C. compared with lower temperatures. This probably was due to a depletion of the melt content of the matrix.

Effect of CO_2

Much simpler operation of a fuel-cell system could be attained if CO_2 addition to the air were not required. In the absence of CO_2 addition to the air, oxide ions from the air electrode reaction

$$\tfrac{1}{2}O_2 + 2e = O^= \qquad (4)$$

accumulate at the electrode-electrolyte interface giving rise to the phenomenon known as concentration polarization. This results in a lower voltage during cell operation.

The effect of CO_2 addition on the open-circuit and operating voltage for the hydrogen-air cell operating at 600°C. using porous nickel electrodes is illustrated in Figure 6. The effect is quite evident and is of the order of magnitude estimated from theoretical considerations.

Cell life and stability

A cell having sufficient stability for commercial use has not yet been achieved, although Ketelaar (7) reported a cell life of six months or more. We have not as yet been able to duplicate this result. The longest period of operation we attained, at full temperature, has been of the order of two weeks.

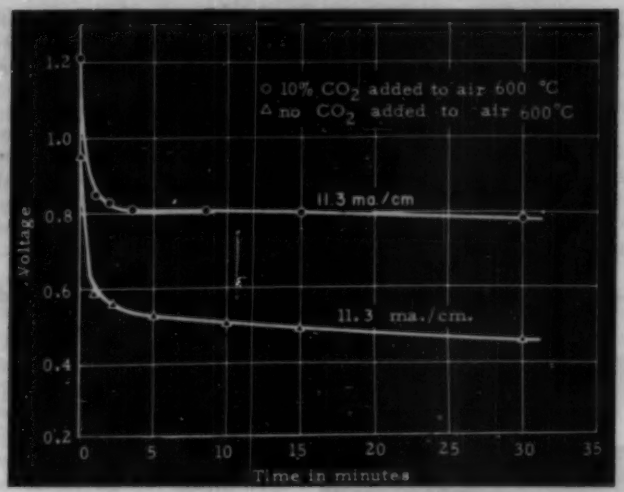

Figure 6. Cell operation as affected by CO_2 addition to air.

No insuperable problems are visualized which would prevent extension of the cell life to long periods. The biggest single factor (as we see it) which would limit cell life, is loss of electrolyte from the matrix. We found that the electrolyte required frequent replenishment. The loss is thought to be due to creep along the metal flanges to areas, where loss of melt by corrosion occurs. This can be minimized by proper cell design.

Corrosion may also be a problem at the fuel electrode for gases rich in CO. Under these conditions carburization of the nickel electrode is observed.

Power generation from fossil fuels

The high-temperature fuel cell must be used as part of an over-all integrated process when it is employed for the generation of power from fossil fuels. Our purpose is to discuss methods for integration of the use of the fuel cell with fossil fuels.

A voltage increase of the order of 0.25 v. is to be anticipated in cell operation by addition of CO_2 to the air. While operation without such addition is not ruled out, it is felt more desirable to provide for such addition. Process equipment is thus required to transfer CO_2 from the spent fuel gas to the air. Such equipment would not be required if complete combustion of the fuel gas could be effected without significant reduction in cell output. At the present state of development this does not appear feasible.

A circulating or cyclical CO_2 acceptor operation has been proposed for this operation *(12)*. Lime or dolomite used as the acceptor would have the advantage that cooling of the gases would not be required before the transfer is effected. The illustrations given are based on the use of a circulating lime acceptor system.

Table 1. Material Balance Around Coal Devolatilization

		LB.	MOLE
IN			
	MAF coal	100	
	CO		0.60
	CO_2		0.38
	H_2		4.50
	H_2O		0.19
OUT			
	MAF char	58.1	
	CH_4		1.75
	CO		0.95
	CO_2		0.42
	H_2		3.51
	H_2S		0.05
	H_2O		0.22

ANALYSIS	H	C	N	O	S	Gross heat value Btu./lb.
COAL	5.74	82.26	1.31	8.13	2.56	14,380
CHAR	0.92	97.10	0.90	..	1.08	14.543

A schematic integrated fuel-cell system operating with gaseous fuels containing hydrocarbons is illustrated in Figure 7. Natural petroleum fuels can be employed or the fuel gas may be generated from coal, as will be discussed later. The fuel cell itself is shown at *D* and consists of a number

Table 2. Composition of Gas Streams In and Out of Fuel Cell in Moles

A. Coal volatiles—% fuel gas burned/pass = 55.5

Stream number	1	2	3	4	5
CH_4	1.75	1.75	0.00		
CO	0.95	1.15	2.68	0.60	
CO_2	0.42	0.22	6.80	0.38	
H_2	3.51	3.31	2.43	4.50	
H_2O	0.27	0.47	4.86	0.19	2.58

Stream number	6	7
N_2	15.95	15.95
O_2	4.14	0.96
CO_2	8.50	2.14

B. Methane feed—% fuel gas burned/pass = 66%

Stream number	1	2	3	4	5
CH_4	1.00	1.00	0.00		
CO		0.15	1.00	0.15	
CO_2		0.27	4.42	0.27	
H_2		1.85	1.00	1.85	
H_2O		0.20	3.05	0.20	2.00

Stream number	6	7
N_2	11.02	11.02
O_2	2.86	0.86
CO_2	5.00	1.00

C. Complete coal conversion—% fuel gas burned/pass = 43.2

Stream number	1	2	3	4	5
CH_4		5.56			
CO		2.71	9.35	1.61	
CO_2		1.05	15.95	0.85	
H_2		12.0	11.65	19.36	
H_2O		2.50	14.00	3.41	2.85

Stream number	6	7
N_2	44.02	44.02
O_2	11.41	3.42
CO_2	22.84	6.85

Table 3. Over-all Maximum Electrical Efficiency

A. Coal devolatilization

	Heat of combustion, Btu.
100 lb. coal to devolatilization	1,438,000
4.8 lb. char burned to supply endothermic heat devolatilization	70,000
	1,508,000
58.1 lb. char product from devolatilization	844,000
Net fuel consumed	664,000 Btu.

Efficiency = 100 × Btu. equivalent of electrical energy at 0.75 v. ÷ net fuel consumed $= \frac{396{,}000}{664{,}000} = 59.7\%$

B. Complete coal conversion

100 lb. coal	1,438,000
Btu. equivalent of electrical energy generated at 0.75 v.	998,000

Electrical efficiency $= \frac{998{,}000}{1{,}438{,}000} = 69.5\%$

C. Methane combustion

1 lb. mole methane In	383,034
Btu. equivalent of electrical energy at 0.75 v.	249,000

Electrical efficiency $= \frac{249{,}000}{383{,}034} = 65\%$

of rectangular elements arranged in parallel, with gas passages disposed between the electrodes. The fuel gas and the air pass countercurrently through each element.

Three sources of fuel gas have been considered. First, the relatively hydrogen-rich gases leaving the fuel cell system may be utilized to effect the high-temperature devolatilization of coal at 1300-1600°F. Data on operations of this kind have been given by Dent *(13)*, and Linden *(14)* as well as in unpublished work from the Consolidation Coal Laboratories. A material balance around such an operation is given in Table 1, based on the use of a Pittsburgh Seam coal from the Ireland Mine in Cresap, West Virginia. The data given in Table 1 are not an actual experimental result but are consistent with the experimental facts obtained in our laboratories. It is noted that a large quantity of char is produced which in an actual case

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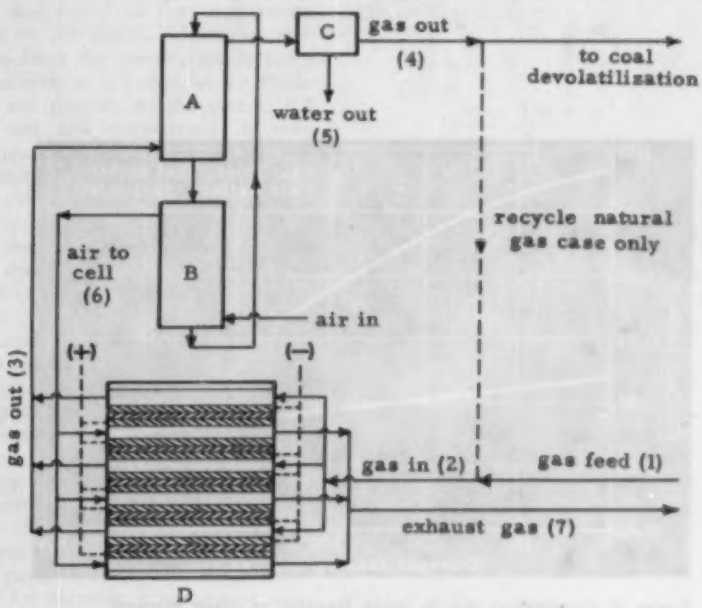

Figure 7. Schematic of integrated fuel cell system.

Fuel cells

Continued

could be used as a fuel for a conventional power plant.

The second involves the use of CH_4 as fuel while the third case includes the complete gasification of the coal by the hydrogen-rich gas leaving the fuel cell system. Work by Dent *(13)* and our own laboratories *(15)* has shown this to be possible although rather elevated pressures, of the order of 20-30 atm. or even higher, are required.

The material balances through the system (Figure 7), operated at 1340°F. are given in Table 2. The numbers given are based on complete elementary balances through the system. The CH_4, CO, and H_2O yields, and the H_2/CH_4 ratio given in the products leaving the coal devolatilization unit are based on our experimental data in this type of operation.

It was assumed that the CH_4 and steam were completely reformed to oxides of carbon, and a water-gas shift equilibrium was established within the fuel cell. The thermodynamic equilibrium is such that it is very closely approached in the presence of a catalyst.

The maximum electrical efficiency that can be achieved in these systems can be calculated from the heat and material balances around the operations shown. The efficiency was calculated on the basis of cell operation at 0.75 v. It is noted that the efficiency obtained based on gross heating value of the fuel varies in the range of about 60% for coal devolatilization to about 70% for complete coal conversion (see Table 3).

The figures shown do not account for certain power requirements for operation of the system. For example, one of the major power requirements is in the compression of the air.

Waste heat, however, is available from the fuel cell operation. Thus, if the gases fed to the cell are preheated to operating temperature, it can be shown that there is a net heat release of approximately 20% of the heating value of the fuel. If a portion of this surplus heat could be utilized to generate steam, enough energy would be made available for operation of the process equipment.

Factors limiting cell performance

The economics of the fuel cell will depend not only on efficiency and cell life, but perhaps equally on the power output that can be achieved per unit electrode surface. Three main factors may be discerned (not truly independent of each other) which limit cell output. It is useful, however, to discuss them separately.

Kinetics of electrode process

The rate of the electrode process determines how close the operating cell voltage is to the theoretical voltage. Polarization, or a decrease in operating voltage over and above the potential drop through the cell, occurs when the rate of the electrode process cannot keep pace with increasing current drain.

Our experimental information is still too meager to define the limitations imposed by kinetics of the electrode processes. Work is now in progress to define to what extent the area of "no polarization" can be extended in the direction of higher current densities and lower oxygen partial pressures.

It has been shown that nickel acts as a polarization-free hydrogen electrode up to 115 amp./sq.ft. current density. Here again experimental work is in progress to define the effect of hydrogen partial pressure, hydrogen-steam ratio, and increasing current density on polarization.

No fully satisfactory electrode is available for operation with CO, as was shown above. This may not be a problem if good performance can be obtained with hydrogen at low dilutions, since the CO in the fuel gas can be consumed as hydrogen by way of the water-gas shift reaction.

Diffusional resistance to active electrode surface

Diffusional resistance from the bulk gas phase to the electrode-electrolyte interface must also be considered a factor that can limit cell output. Thus, in the limit, at high current drains, the operating voltage will decrease to zero when the diffusion rate cannot supply fuel to the electrode as fast as it is consumed.

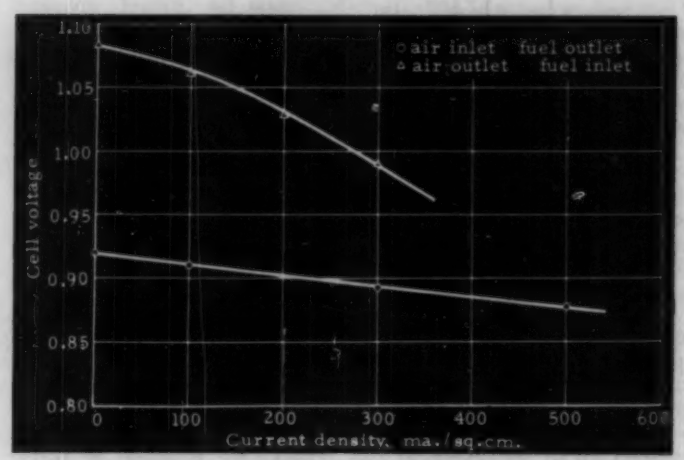

Figure 8. Polarization due to mass transfer of gases through electrodes.

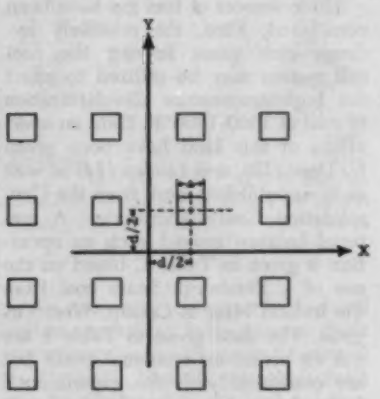

Figure 9. Simplified model of electrode contact.

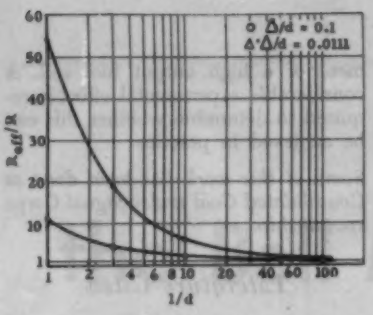

Figure 10. Effective resistance ratio.

It is possible to approximate the effect of diffusion rate in cell performance by the method of Hougen and Watson (*16*). The model chosen is a plane porous electrode of thickness B_G and porosity α. It has been shown that the interdiffusion coefficient (*17*) of a gas A against another gas M through a porous medium of porosity α can be approximated by the expression $D_{AM}\alpha$. The method then consists simply of equating the rate of consumption of the gas at the electrode to the diffusion rate and thus calculating the concentration of the gas at the electrode interface. In this way the diffusion of oxygen can be calculated from the equation:

$$2.58 \times 10^{-4} i = -\frac{D_{O_2M}\alpha\pi}{3B_G R T} \ln\left(\frac{\pi - 3p_{O_2}}{\pi - 3p^{i}_{O_2}}\right) \qquad (5)$$

The effective concentration of all the gases at the electrode-electrolyte interface were determined this way. The theoretical voltage, excluding the potential drop through the cell, was thus calculated as a function of current density by application of the Nernst equation.

A countercurrent cell system (Figure 7) was used and calculations were based on the gas compositions of Table 2 for Case A. The inlet gas composition was changed from that given, assuming that the CH_4 was converted to CO and H_2 by reforming over the nickel catalyst.

The effect of current density on the cell potential calculated this way is shown in Figure 8. The values of B_G and α used were 0.2 cm. and 0.40, and corresponded to the particular electrodes used in our experimental work. It is easy to convert the figures given to any other values of B_G and α by compressing the abscissa in proportion to the factor B_G/α.

It was noted from our experimental work that no polarization effect on the air and hydrogen electrode was observed at current densities up to 125 ma./sq. cm. The calculations of Figure 8 bear out the fact that no diffusional resistance should be encountered at this level of current drain. They also show that only a very small diffusional resistance is to be expected in cell operation up to 250 ma./sq. cm. (232 amp./sq. ft.).

Internal resistance of the cell

The largest single factor limiting power output of the cell is the large internal resistance of our present setup. Thus, it is noted from the performance data given in Figure 4 that the IR drop at a current density of 100 amp./sq. ft. is of the order of 0.5 v. which corresponds to a 5-ohm resistance/sq. cm. of electrode area.

It has been stated (*1*) that a commercial cell should operate at a current density of about 200 amp./sq. ft. To retain the advantages of a high thermal efficiency an operating voltage of at least 0.75 v. should be maintained. It should be clear from Figure 8 that effective resistance/sq. cm. of the cell can be no greater than 1.1 to 1.2 ohm, or a factor of 4 to 5 less than that observed.

Measurements were made of the specific resistance of the magnesia matrix fully loaded with a mixed carbonate melt, using two flat silver gaskets as electrodes. An average value of the resistance/sq. cm. of about 0.7 ohm was found in the temperature range of 700-800°C. The value estimated from the specific conductivity of the melt of 2.9 ohm, at the thickness and porosity of the matrix, 0.2 cm. and 28% respectively, is only 0.25 ohm. The resistance of the electrolyte matrix is thus low enough to give the desired performance level.

It is believed that the high resistance during cell operation is due to a high contact resistance both between the electrodes and the matrix and between the electrodes and the metal conductor. The high contact resistance arises from the necessity of maintaining just the right amount of melt in the system such that the electrode is not flooded with melt, but maintains contact with it.

Since no real positive control of the melt content can be maintained in the cell of the present design, good operation probably obtains only when random point contact is effected. Consider, for example, a wire-gauze electrode where contact is maintained only at the points where the wires intersect. A simplified model of such an electrode with square areas of contact is shown in Figure 9.

The effective resistance of a cell containing two such identical, infinite, plane, square-mesh electrodes, separated by an electrolyte of thickness l, may be calculated by a solution of Poisson's equation, which relates the potential V to the position in the electrolyte. It may be written in the form:

$$\nabla^2 V = -4\pi\rho = 0 \qquad (6)$$

where ρ, the net charge density, is zero throughout the electrolyte. The calculation desired is the potential drop across such an electrode system as a function of the current density i, and the specific resistance R. This can then be compared with the potential drop across plane, flat electrodes. The above partial differential equation was solved with boundary conditions corresponding to a constant flow of current to each active square electrode area:

$$\frac{\partial V}{\partial Z} = \frac{iR}{r^2} \text{ at } Z = l/2 \text{ and } Z = -l/2 \qquad (7)$$

when x and y simultaneously lie within the regions

$$\left|\frac{(2n+1)d - \Delta}{2}\right| < |x| < \left|\frac{(2n+1)d + \Delta}{2}\right|$$

where $n = 0, 1, 2, 3$, etc.

$$\left|\frac{(2m+1)d - \Delta}{2}\right| < |y| < \left|\frac{(2m+1)d + \Delta}{2}\right|$$

where $m = 0, 1, 2, 3$, etc.

$\frac{\partial V}{\partial Z} = 0$ elsewhere on the electrode surfaces,

and $r = \Delta/d$.

continued

Fuel cells

Continued

The solution of the above equation obtained by Fourier analysis may be written:

$$V = C + iRZ - \frac{iRd}{\pi^2 r}\sum_{m=1}^{\infty}\frac{\sin m\pi\,(1-r)\sinh\left(\frac{2\pi mZ}{d}\right)\cos\left(\frac{2\pi my}{d}\right)}{m^2\cosh\left(\frac{\pi ml}{d}\right)}$$

$$-\frac{iRd}{\pi^2 r}\sum_{n=1}^{\infty}\frac{\sin n\pi\,(1-r)\sinh\left(\frac{2\pi nZ}{d}\right)\cos\left(\frac{2\pi nx}{d}\right)}{n^2\cosh\left(\frac{\pi nl}{d}\right)}$$

$$+\frac{2\,iRd}{\pi^2 r^2}\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}\left[\frac{\sin n\pi\,(1-r)\sin m\pi\,(1-r)}{nm\sqrt{n^2+m^2}\cosh\left(\frac{\pi l\sqrt{n^2+m^2}}{d}\right)}\right]\cdot$$

$$\left[\cos\left(\frac{2\pi nx}{d}\right)\cos\left(\frac{2\pi my}{d}\right)\right] \qquad (8)$$

The ratio of the actual resistance to that for plane electrodes may then be written:

$$\frac{R_{ett}}{R} = \frac{V_{x\,=\,1/2,\;z\,=\,d/2,\;y\,=\,d/2}}{i\,R\,l} - \frac{V_{x\,=\,-1/2,\;z\,=\,d/2,\;y\,=\,d/2}}{i\,R\,l} \qquad (9)$$

The resistance ratio calculated in this way is graphically illustrated in Figure 10, where R_{ett}/R is plotted as a function of l/d, with Δ/d as a parameter. The wire-gauze electrode used in our experiments was 80 mesh. If every wire junction actually contacted the electrolyte $l/d = 6.3$.

A value of $\Delta/d = 0.1$, *i.e.*, $\Delta = 0.032$ mm. would explain the observed resistance ratio of about 8. The actual area covered by electrode contact would thus be 0.01 of the total area. Thus, relatively poor contact could easily explain the observed high resistance.

To improve the situation it is necessary to improve control over the contact. This can be achieved, in principle, by using pressurized double-porosity electrodes, similar to those used by Bacon in the hydrogen-oxygen cell. Electrodes of this type are under development at present.

Consider, for example, an electrode where the contact spacing is at intervals of 50μ, (a pore size of 31μ with about 40% porosity). l/d in this case would be about 40. It is clear from Figure 10 that even if $\Delta/d = 0.01$ or $\Delta = 5 \times 10^{-4}$ mm., that the resistance ratio would be only about 1.5 and the resistance/sq. cm. would be brought down to the level of 1 ohm as needed for a current output of 200 amp./sq. ft. at 0.75 v.

One source of polarization is in the three-phase limit where gas, electrolyte, and electrode meet. If this is a geometrical line, it is obvious from Figure 9 that the cell resistance would be infinite. Permeation of the gas through the electrode is required to broaden this line to values of the order given above. It is clear then that a close spacing of the contact areas shrinks the dimensions of the permeation path to practical and achievable dimensions.

It is concluded, that no theoretical reason exists to prevent the attainment of a high output fuel cell. A considerable experimental effort is required to determine whether this can be achieved in practice.

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the Ball Mill for pigment dispersion and grinding

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In the past twenty-five years, the usefulness of the ball mill for producing paints, inks, and various kinds of coatings has improved tremendously. This change has been brought about by the use of larger ball charges, smaller ball sizes, higher mill speeds, larger paste volumes, higher pigment concentrations, and low vehicle viscosities. Products that formerly required as long as 30 to 70 hours can now be ground and dispersed in a matter of 4 to 8 hours. The shorter processing time in many cases produces a superior product with less contamination.

The approach to a problem of wet grinding for size reduction, or of pigment dispersion into a product might follow this sequence:

1. Select the highest density grinding media permissible from a contamination, cost, and process standpoint.
2. Select the smallest ball practicable; the size is limited by physical conditions, retention of product in the mill, particle size of the solids initially, consistency of the paste, cost, or availability.
3. Select the lowest vehicle viscosity possible, with due consideration for the effect of dispersants, flocculants, and temperature.

When the above selections have been made and mills are operated at about 65% of critical speed with 50% by volume of ball charge and paste charge (80% total), the result will be a fast, economical, size reduction or dispersion.

Grinding media

The highest density grinding media commonly in use is steel of sp. gr. 7.8. The ball used must be both hard and tough. By experience and long usage, an alloy steel ball (Molloy) of about 63 to 64 Rockwell C hardness throughout has been found to be very satisfactory. The alloy content of the ball is low, and the forming techniques follow those for conventional steel products. Balls of greater hardness will show chipping and splitting, while lower hardness will show greater wear rates. Balls of 62 Rockwell C hardness wear twice as fast as those in the 63 to 64 range. With good usage the ball wear is about 8 to 10%/yr. of 8000 hr.

The ball charge should be sorted to size once a year, or discarded every five years. After about five years of use the ball is about half the original weight. A ¾-in.-diam. ball will have been reduced to ½ in. Smaller balls mixed with ¾-in. balls wear at a greater rate. Where contamination is a problem, the use of mixed sizes has been found to give greater contamination. A half-and-half mixture of ½-in. and ¾-in. balls will show 2 to 3 times the wear rate of ¾-in. balls alone.

For a nonmetallic grinding media, a tough, hard ball has been developed that is composed chiefly of alumina. The hardness of this ball is approximately nine on the Moh scale. This ball has a sp. gr. of 3.3 to 3.5 and has often replaced the porcelain ball (sp. gr. 2.4) and the flint pebble (sp. gr. 2.6). The latter two have a hardness of about eight, and show wear rates of from 2 to 20 of those encountered for the tougher and harder alumina balls. The ingredients used for making ceramic balls are ground to about six fineness on the Hegman gauge. The best flint pebbles are of fine texture and have no defects or occlusions. The particles that wear from fine-textured flint and well-made ceramic balls are of small particle size, in the micron size range, and are generally not visible in the product. In some cases where an opaque contaminator is readily discerned, the porcelain ball is used, because the silica base is more translucent.

Grinding media size. The ball size, ball density, ball velocity, paste density, pigment concentration and size are all related. An empirical correlation of these factors has been attempted. It is believed that effective grinding or dispersion is related to ball velocity. This velocity should possibly be in a narrow range, as high as possible and yet not so high as to cause failure of the bond holding the grains in the ball together. It is believed that the velocity of the ball may be influenced by the factors associated with freely falling bodies and follows the laws developed by Stokes. The law may be expressed:

$$V = \frac{C g_c D^2 (S_s - S_l)}{18n} \qquad (1)$$

where:

V = velocity, ft./sec.
C = constant
g_c = acceleration of gravity, 32.2 ft./sec./sec.
D = diameter, ft.
S_s = density of solid, lb./cu. ft.
S_l = density of liquid, lb./cu. ft.
n = viscosity, lb. mass/(ft.) (sec.)

Attempts have been made to prove the validity of this law by measuring the velocity and thus determining the value of the constant. Pictures taken through the end of a revolving mill have established that the balls do not move at the same velocity in clear liquids as in pigmented systems of the same viscosity. In a pigmented system suitable for good grinding, the speed of the cascading balls is about equal to the peripheral speed of the mill which is about 65% of critical speed. The velocity of the balls becomes more uniform as the speed of

rotation is increased, until the speed is so high that some of the balls are free falling and "cataract" across the mill becoming subject to damage; *i.e.* the balls are thrown outward above the inclined surface and drop upon it at some point further down. In this discussion, it is assumed that a 50% ball charge and 70 to 80% total charge (material plus ball) are being used.

The viscosity factor is another term that is difficult to determine for a pigmented grinding system. If one uses a Brookfield viscometer, the viscosity values will show 15,000 to 20,000 centipoise (cp.). If a clear liquid of the same viscosity is substituted for the pigmented paste, the velocity in the clear liquid will be seen to be much slower than for the pigmented paste. Referring to Figure 1, in which torque number and Reynolds number are plotted for rotating elements, it will be observed that conventional cylinder type viscometers operate at Reynolds numbers of 0.1 to 0.2; this would be 10 to 20 r.p.m.

In a ball mill the fluid is believed to be in turbulent motion, or possibly in the *critical* region. A viscometer should therefore measure the viscosity of pigmented systems at a sufficiently high shear rate to represent the viscosity of the pigmented paste in the ball mill. A viscometer that can measure the viscosity at a Reynolds number of 3 to 5 is the Krebs modification of the Stormer viscometer. This viscometer rotates at about 200 r.p.m. and has a larger diameter so that the consistency is measured at relatively high Reynolds number as indicated in Figure 1, and it does operate normally at relatively high shear rates. The viscosity values translated to equivalent Newtonian liquid values would be 1000 to 3000 cp. for the same pastes measured on the Brookfield at 15,000 to 20,000 cp.

In a pigmented system of kerosene and quartz, it has been established that the constant in Equation (1) is about 0.1, based on the viscosity as measured in a Stormer viscometer using the Krebs modification. If the viscosities were measured at high shear rates, it is possible the viscosities would decrease and the constant would be a larger value; believed to be between 0.5 and 1.0, but due to difficulties of velocity measurement in a pigmented system, and of viscosity measurement at relatively the same shear rate as occurs in the ball mill, more work is necessary.

The ball size, ball density, paste density, and paste consistency, however, do bear relationships to each other that follow Stokes law. A common grinding system is one in which 1¼ in. Arlcite balls are used to grind a paste weighing 15 lb./gal. and the consistency is 125 KU (Kreb Units), (about 3300 cp.). If the paste, on the other hand, weighs only 10 lb./gal., a 1-in. ball will give the shortest grinding cycle.

Dispersion of black pigments in pastes that weigh 10 lb./gal. is carried out in the shortest time with ¾ in. steel balls of 125 KU consistency. On the other hand, if the consistency is 70 KU (600 cp.) for example, for a finished product dispersion, the ¾-in. diam. steel ball will give the shortest grinding time. All the above results would have been predicted from Equation (1) if the velocity term remained the same.

There is a tendency to use large balls because they are cheaper and more wear can be obtained from them than from the smaller balls. But the primary use of balls is not to wear them smaller, but to obtain a dispersion of a product. The use of large balls is steadily being discouraged. Table 1 indicates the change in size required for various size balls to obtain the use of half the weight of the ball. A rather nominal change in diameter results in a large weight change.

Table 1. Diameter of ball at 50% original weight.

Diameter of Ball Charged (inches)	Diameter of Ball When Half Used (inches)
½	0.40
⅝	0.50
¾	0.59
1	0.79
1¼	0.99
1½	1.18
2	1.58

It is suggested that ball volumes in the mill be brought up to operating level every three months and that once a year the undersized be removed. The balls should be culled close to the 50% values of the weight of the balls originally charged to the mill as indicated in Table 1. It has been observed that when balls are used longer than this, the mixture of balls results in higher wear rates. The small balls culled out of each batch should be saved and used for special mills in which products of lower consistency are dispersed or sold to operators who use the smaller sizes. The

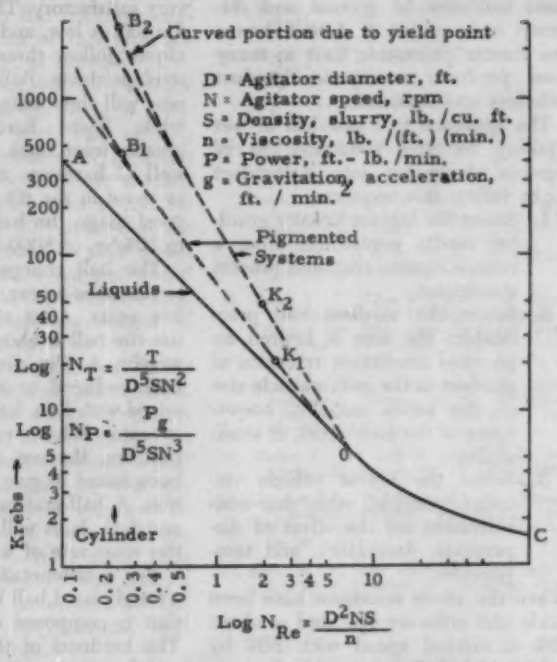

Figure 1. Power or torque number relationship to Reynolds number for rotating type viscometer.

size of ball used in the mill may be dictated by the size of the openings in the mill discharge grate, the viscosity of the vehicle, the amount of paste retained in the mill upon discharge, and the rate of mill discharge. As the vehicle solids of the paste in the mill is decreased, the holdup in the mill will decrease and smaller balls can be used.

The openings in the discharge grate can be reduced to ¼-in. slots and still not interfere with the free discharge of the mill. A study of mill additions for "let-down" can result in data for obtaining a paste of low consistency that is free flowing and with low vehicle solids. This paste will then show very little holdup or product in the balls even though small balls are used. Dispersion and size reduction are completed much quicker with small balls. In tests with 0.5 in. and 1.25 in. Arlcite balls, the time to obtain a fineness of 7.5 Hegman North Fineness was found to be 4 and 18 hr. respectively. This test was made at consistences of 63 and 115 KU in a pigment resin (solvent system using 18% vehicle solids). In another test using steel balls, 19/32-in. balls required half the time to obtain a dispersion as 1.0-in. steel balls. Both of these tests were made at 50% ball loading, with mills operating at 65% of critical speed, and 1.1 material-to-void ratio.

These tests show that the time of dispersion is inversely proportional to the area of balls per unit volume. This is the expected result if the dispersion is accomplished primarily by shear due to spinning of the balls. *The much shorter processing time that results from the use of small balls is very rewarding.* Factors that limit the ball size as mentioned earlier can often be corrected.

Dispersion consistency

There has been a growing need for operation of ball mills at controlled consistencies and a definition of a basis for the value used. Much of the laboratory work in ball mills is based on the use of 1-in. Porox balls and ½-in. (and smaller) steel balls.

Laboratory test work was carried out to determine the relationship between ball wear and consistency. It was found that if the ratio of the square of the *diameter* of the ball and the *consistency* was held constant, the weight-percent loss would be the same. For example, a ½-in. Arlcite ball tested in a formula at 63 KU had the same wear rate as a 1¼ in. ball at 125 KU.

From the results of similar tests it was established that ball wear can be held to values of 5 to 8%/yr. of 8000 hr., if the ball size and consistencies are held in the range of values shown in Table 2. As the consistency is decreased, the wear rate will increase rapidly, more for larger balls. For example, 1¼ in. Porox balls will show 0.1% loss in one hour in water, while 2-in. balls will show 0.5% loss in one hour under the same conditions.

Table 2. Consistency of finished dispersion.

Ball Diameter (inches)	Porox	Arlcite	Steel
¼	—	28-38	61-71
½	37-47	53-63	85-95
¾	55-65	63-72	101-111
⅞	63-77	70-80	114-124
¼	78-87	94-104	125-134
1	98-105	111-121	141-151
1¼	109-118	125-135	—
1½	120-129	135-146	—
2	137-146	—	—
Density g./ml.	2.38	3.3	7.85

It will be noted that the values given in Table 2 are in agreement with the relationship given in Equation (1) for ball diameter, consistency, ball density, and paste density. The table is based on density of 110 lb./cu. ft. (15 lb./gal. or 30 oz./pt.). Corrections can be made for other paste densities as indicated in Equation (1) and the discussion in the previous section.

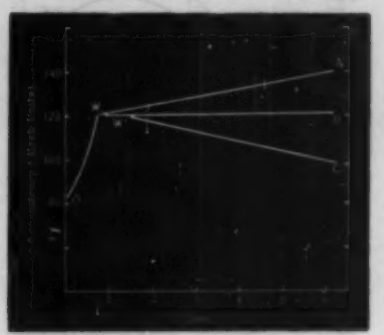

Figure 2. Effect of grinding time on consistency of paste being ground.

When a pigment is being dispersed, the consistency of the paste may change in several different ways. In Figure 2 are shown typical curves representing the change of consistency with time of dispersion. The curve from *O* to *W* is the consistency increase obtained in a ball mill resulting from mixing of the ingredients and removal of gas in large volumes. The consistency increases more rapidly as the clumps are broken up. A material that is easily dispersed and contains only a few aggregates will follow the line *WB*. Agglomerates are formed about as fast as aggregates are broken up, and the resulting plasticity remains approximately the same as at *W*. Many products follow this pattern and product quality is measured by fineness readings as determined on a Hegman gauge or by examination of the product.

The line *WA* is obtained if the solid is being reduced in particle size, or if very small agglomerates are formed. The consistency increase indicates an increase in population of particles of smaller size. Materials that exhibit a decreasing consistency and follow the line *WC* are believed to be forming larger agglomerates and in effect, decreasing the particle population. This pattern is obtained when insoluble resins or gels are used. These tend to form large agglomerates.

Vehicle viscosity. The viscosity of the vehicle should be as low as can be permitted by the dispersion or fineness that must be produced. A resin, oil, or other dispersant is often used to secure the degree of flocculation desired in the finished product when preparing a dispersion. When these are used in the vehicle, they increase the viscosity and interfere with release of adsorbed gases. The maximum amount of resin or other dispersant to use with a given pigment has been investigated by many. An easy titration method devised by Daniel (*1*), permits the determination of the amount of resin required for a given pigment–resin–solvent system. Different pigments require vehicle solids in the range of 10 to 20%. This test gives the maximum amount of solids required, and in many cases can be reduced to half these values and still obtain satisfactory flocculation. Where tinting solutions are used, it is often desirable to have a uniform solids content in which case, the lowest value found by these tests is used.

The viscosity of solutions can also be lowered by using higher temperatures, and lower grade solvents which tend to throw the resin or other dispersant material out of solution. The use of nonpolar solvents is of advantage with many oxide pigments. The resins tend to go with the pigments, and thus decrease the viscosity of the vehicle while the dispersion is being

made. If the viscosity of the vehicle is above about 30 cp., the time to prepare a dispersion is increased. Generally, solutions of low viscosity contain enough resin or other dispersant to produce the product desired.

Material-to-void ratio. The volume of voids between the balls of uniform size as, used in a ball mill, is approximately 40% of the volume occupied by the balls. To just fill the voids of the balls in a mill filled with balls to 50% of the volume requires a slurry volume of 20% of the mill volume. The shortest possible dispersion or grinding time is obtained when a paste volume of this size is used. If a smaller volume is used, excessive wear of the balls may result.

In general, for batch operation, material volume to void volume of 2.0 to 2.5 is used. For a 50% ball charge this would be 70 to 80% of total mill volume filled with balls and material. Some 30% of the mill volume would be actually balls and 40 to 50% of the mill volume would be material in the interstices and above the balls. The amount used may be dictated by the volume of the dry pigment when charged.

The time to disperse or grind the larger batches is not in proportion to the increase in volume of paste handled. Generally a batch with material-to-void ratio of 2.5 will require about 50% more time than the minimum batch size with a material-to-void ratio of one. An exception to this statement may be found with carbon blacks which usually require proportionately greater time.

Mill speed

A plot of mill speed as a function of critical speed, indicates that horsepower requirements are roughly proportional to the speed, up to a critical speed of 50% as indicated in Figure 3. The power required for 30, 40, and 50% ball loading is indicated. The power is less than the linear relationship above a critical speed of 50% and reaches a maximum value at 82% of critical speed. The speed for wet grinding has been selected to be between these two values, and was finally chosen on the basis of experience. For steel ball mills the speed selected is 65% of critical speed, while for lined mills, 60% of critical speed was selected. As the lining of the mill wears away, the speed approaches 65% of critical speed.

Figure 3 indicates the speeds at which the outer row of balls was observed to break away from the mass of balls and "cataract" to the toe of the heap. These data were obtained for solvent slurry system with baffles. For 50% ball charge this was at 68% of critical speed, whereas for 30% ball charge this was at 63% of critical speed. In a pigmented system cataracting is more difficult to see, and if the consistency of the batch corresponds to values given above, it occurs at about 70% of critical speed in unbaffled mills. When a Newtonian liquid of 1500 cp. is used, this value for initial cataracting of the balls occurs at 50% of critical speed. The outer row of balls centrifuges around the mill at 65% of critical speed with this Newtonian liquid. This is the reason that liquids of Newtonian viscosity can not be substituted for a pigmented system to study the action in a ball mill.

Optimum results can be obtained for grinding and dispersion when critical speeds of 65% and 60% are used for steel balls and ceramic balls respectively. No baffles are required, and the greatest amount of shear force due to spinning of the balls is obtained. The apparent volume of balls seems to increase at these speeds as compared to operation at 50% of critical speed.

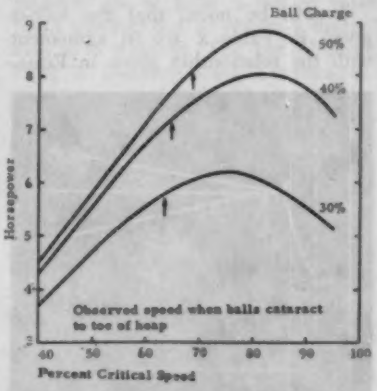

Figure 3. Variation of power requirement through range of speeds with changes of percent ball charge.

To give long-time maintenance-free operation, ball mills should use babbitt bearings and fine tooth gears. The lined mill in Figure 4, has self-aligning babbitt bearings and trunnions machined at the same time the ring gear is machined, to give good alignment of the drive and bearings. The drive is on a common base and set to permit adjustment to maintain proper gear tooth contact. Low starting torque can be obtained for this mill if the bearings are lubricated with greases containing molybdenum.

Higher mill speeds decrease processing time more than would be expected from a consideration of power increase alone. In a ceramic mill where the speed is changed from 50% to 60% of critical speed, the processing time should be about 80% of that formerly required. When fine products such as clays are dispersed, this decrease in time has been observed to be as much as 60%. This result may be due to the higher shear rate produced by the balls, and by the increased mixing obtained when large batches are prepared.

Ball charge. The choice of size of ball charge is primarily a consideration of slippage between the mill shell and the balls. With a low ball charge, 33%, the slippage at 60% of critical speed is about 12%. This is measured

Figure 4. A lined mill with babbitt bearings. (Patterson Foundry & Machine Co.)

by the power input to the mill and can be eliminated by the use of large baffles—twice as high as the diameter of the ball. On the other hand, a 50% ball charge at 60% of critical speed has a slippage of about 2%. The use of baffles in this case would show very little benefit.

Gow (2) reported the first extensive study of ball milling nearly thirty years ago and suggested that ball charges above 45% of the volume of the mill would show little slippage if no baffles were used. This was substantiated for wet grinding with batches of ball mill paste. Because steel balls show less slippage than ceramic balls, ball charges for steel of 45% have been selected as most favorable, while for ceramic balls a 50% charge is used.

Ball shape. Numerous tests have been made to show that cylinders or "natural" shapes give superior performance. In every case where such results have been obtained, the result has been due not to the shape, but to the smaller size grinding element. For example, if 13/16 in. cylin-

ders are substituted for 1¼-in. round balls, the time to obtain the dispersion or grind will be about 0.6 of the time required for the larger balls. Had the comparison been made with cylinders and balls each of the same weight and size, for example, Arlcite of 13/16 in. in each case, results would have shown that the balls can produce the same dispersion as cylinders in 75% of the time. This is believed to be due to the greater rate of spinning obtained with balls as compared to cylinders. The results for "natural" shapes falls between that required for balls and cylinders. Another disadvantage with the use of cylinders is the smaller percentage voids. This means a greater weight of grinding media is required, more power is required to drive the mill, and the holdup is greater in the mill upon discharge when a cylindrical shape is used.

Baffles or lifter bars. Directly associated with ball charge volume is the question of the use of baffles in the ball mill. When the above ball volumes and mill speeds are used, there is no need for baffles. However, when operating mills at lower ball loading and lower speeds, it is desirable to use baffles. These baffles should be welded to the shell and terminate at least one ball diameter from the head of the mill. To be effective, the baffles should not be less than two ball diameters high. A disadvantage of baffles is the more rapid wear of the shell in back of the baffles. To overcome this difficulty wide 4-in. blocks are used as lifter bars. The best practice is to use 60-65% critical speed, high density balls, 45% or more ball loading, high paste consistency, and no baffles. This will reduce shell wear and obtain long mill life. Normally, this is 10 years, but has been as long as 20 years.

Mill diameter. The mill diameter must be considered as a variable in the handling of dispersions and size reduction. Larger mills give faster results than smaller mills, other conditions being the same as outlined previously. The reason for the faster results is probably due to more intense action as a result of more power input per unit volume for the larger mills. The horsepower required to turn a mill varies as the 2.6 exponent of the diameter, while the volume varies as the 2.0 exponent of the diameter. In most cases, it has been found that this change in power required for larger mills does result in shorter operating time. The relative times for production is indicated in Table 3.

Table 3. Relative time for dispersion.

Mill Diameter (feet)	Relative Time for Dispersion
1	1.0
2	0.67
3	0.53
4	0.45
5	0.38
6	0.34
8	0.29

The following conditions should be used for maximum output from ball mill equipment.

1. Grinding media of the highest density possible will give best results.
2. The smallest ball will give the fastest dispersion.
3. The paste consistency should match the ball size used.
4. The vehicle viscosity should be as low as possible.
5. The material-to-void ratio should be in the range of 2.0 to 2.5. The paste volume is then 36 to 50% of the mill volume.
6. The mill speed should be 60 to 65% of critical speed.
7. The ball charge should be 45 to 50% of the mill volume. This is 27 to 30% of the absolute volume of the mill, because balls have about 40% voids.
8. Baffles are not required in ball mills when operated as given above.
9. Large diameter mills have shorter dispersion times than the small mills.

Operation of the ball mill

The charging of ingredients into the ball mill should be done in such a manner as to avoid contact between the pigments and the high viscosity liquids. Pigments have a high absorption power for the solvents in the high viscosity liquids. This leaves the resins in nearly solid form, which then occludes the balls into larger masses. Several techniques can be used to avoid this contact:

1. Premixing of the liquid ingredients in separate tanks. The use of base solutions for this purpose is very common.
2. Premixing the solvent and resins in the ball mill before adding the pigment.
3. Premixing all the ingredients that go into the ball mill in vertical dispersion mixers.
4. Addition of the resin solution, *then* the solvent, and finally the pigment.
5. The addition of the ingredients to the mill should be done rapidly and the mill started as soon as possible.

Where only a few formulas are made in one mill, it has been found expedient to premix the ingredients in a vertical mixer. For this purpose a mixer having an agitator requiring about 0.8 hp. of power per 100 gal. of mix gives excellent results. Solvent and pigment are usually mixed, and the resin or varnish added last. Nearly all the dispersion can be accomplished in this type mixer, and the ball mill is required to do only a small part of the total job. For fineness of 4 or 4½, it is sometimes possible to accomplish the entire dispersion in the mixer.

The impeller used for this mixing can be one of several designs and should have a large sweep, compared to the vessel diameter. Usually 65 to 75% of the vehicle is charged with all the pigment to make a very heavy paste. In a short time a smooth, buttery paste is produced and the rest of the solvent added to bring the consistency to ball mill usage. When in operation, ball mills tend to heat the product being dispersed and to raise the pressure in the mill. The gas released from the surface of the pigment also raises the pressure in the ball mill. For this reason, the mill should be vented about an hour after the dispersion has been started. The venting decreases the partial pressure of the fixed gases and so helps to desorb the gas from the surface of the pigment. Vent plugs that can be opened for release of gas pressure are usually available at both ends of the ball mill. With solvents of high vapor pressure, or if cooling water is not used, it is sometimes necessary to vent the mills a second time, about four hours after startup.

Ball mills are cleaned by addition of solvent after the mill is unloaded. If possible, this solvent should be such that it can be added directly to the product, and thus make certain all the solids intended are used in the batch. Sufficient solvent to fill all the voids is not necessary. It is very important that the mill be operated only a few minutes to keep the wear of the balls to a minimum. Usually one washing is sufficient, unless there is a major color change and the new and old colors when mixed, form grey.

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EDUCATION

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Part one:

Chemical engineering Education in the U.S.S.R.

DURING November, 1958, a team of eight Americans composed the "Engineering Education Exchange Mission to the Soviet Union." The mission was made possible through the Lacey-Zarubin agreement and was sponsored financially by the National Science Foundation through the American Society of Engineering Education. The general report on that mission has now been published *(1)*.

The purpose of this report is not to duplicate the information in the above report, but to emphasize some points as they apply to chemical engineering in particular rather than to engineering in general. In order to understand many of the things that go on in the Soviet Union and to comprehend why the educational system there operates as it does, some background information is required.

It is necessary to understand that in the USSR the welfare of the individual is always secondary to the welfare of the state as a whole. The individual must subjugate himself to the needs of the state. The primary purpose, therefore, of higher education is first to train well-qualified individuals for the service of the state, and only secondarily to develop educated persons.

The institutions of higher learning are divided into three categories. In the first category are the universities under the control of the Ministry of Education. The great majority of students who graduate from the universities are employed as teachers in the secondary schools. Only a limited number of these students are employed by the industry, while the best students go into teaching and research in the institutions of higher learning.

The second category of institution is known as the technical institute. They are also under the Ministry of Education. There are various types of technical institutes whose purpose is to train people for the professions. The technical institutes which train students to become engineers are called VTUZ's. Other technical institutes train people for different professions, such as the medical profession, the language profession, etc. The great majority of graduates of the VTUZ's are employed by industry. Here also the top students either go into full-time research at the Academies of Science, or into combination teaching and research positions with the VTUZ's.

The third category of institution engaged in higher learning is the Academy of Science. These institutions do not report to the Minister of Education but to the Ministry. While the Academies of Science are primarily research institutes, they give advanced degrees at the Kandidate and Doctoral levels. It appears that about one third of the advanced degrees are given by the universities, about one third are given by the various professional technical institutions (including the VTUZ's) and the final third by the Academies of Science.

The students who complete the five- or five-and-a-half-year courses at the universities or the technical institutes receive a diploma. The diploma is not considered a degree, but the possession of a diploma is very important for the future well-being of the student. This is the major reason for the high motivation of the students in both the universities and the technical institutions. When the student obtains the diploma he has reached an intellectual achievement somewhat above the bachelor's degree in the United States and somewhat less than the master's degree.

There apparently is nothing in Russia comparable to the complete university which is so familiar in the

Entrance to Mendeleyev Institute of Chemcal Engineering in Moscow. (L. to r.) Prof. Al Guy of Purdue and S. Kusman, an interpreter.

United States. The universities confine their work to the humanities and the so-called "pure" sciences, whereas the VTUZ's confine their activities to the so-called "applied" sciences. Even though some of the VTUZ's are called polytechnic institutes, there are no complete engineering institutions similar to those which exist in the United States. A polytechnic institute may consist of about 10 to 15 specialities in two or three of the broad areas covered in the U.S. by aeronautical, civil, chemical, electrical, mechanical, or metallurgical engineering. No single institution gives curricula in all of these broad areas.

Since entrance into the institutions of higher learning is controlled by a limited quota, the competition to get into the institutions of higher learning is severe. The entering student must select not only the general area in which he would like to study, such as chemical, civil, electrical or mechanical engineering, but also the specific specialty within the general area. The number of students admitted is based on the estimated number of jobs that will be available in each specialty five years hence. Thus, the entering student at about seventeen years of age is selecting his life work down to the specialized industry in which he hopes to be employed and from which there is little chance of escape.

The place of chemical engineering

The previous statements apply to all students entering any phase of engineering. Chemical engineering is taught as a variety of specialties in both separate chemical engineering institutes and in polytechnic institutes.

According to Prof. N. M. Zhavoronkov, director of the Mendeleyev Chemical Engineering Institute, there are 10 specialized chemical engineering institutes in the USSR which train students wholly for the various food, textile, and leather industries at addition there are 13 specialized technological institutes operated by the food, textile and leather industries at which chemical engineers are trained, as well as three operated by the petroleum industry and four by the metallurgical industry. In addition, 19 of the 25 polytechnic institutes have chemical engineering departments.

Probably the two leading chemical engineering institutions in the USSR are the Lensoviet Technical Institute in Leningrad and the Mendeleyev Chemical Engineering Institute in Moscow. The range of competence of the institutions giving chemical engineering courses in Russia has about the same spread as that from the top to the bottom institution giving chemical engineering in the United States. However, it appears to this observer that chemical engineering *per se* in the USSR is somewhat behind that in the United States at the present time. This was explained by various persons as due to the fact that the USSR is now in that stage of its economy where it is building its capital goods industries. Thus the major effort has gone toward development in the electronic and mechanical areas rather than in the chemical areas.

According to the plan, the amount of consumer industry development will increase rapidly in the next five to 10 years. Then a need for more rapid development of chemical engineering will be evident. This theory was verified by the fact that in several instances the visiting delegation was shown plans for expansion and actual spaces in laboratories where equipment was to be installed for chemical engineering students' use in the years 1960 or 1961.

While the quota for students in chemical engineering curricula in the Moscow-Leningrad area is being held either constant or dropping slightly, the writer was told by Mr. Mozhko, Assistant Minister of Education for Planning, that the number of chemical engineering students in the eastern part of the USSR would increase rapidly during the coming seven year plan. Thus, before the end of the present seven year plan, the total number of chemical engineering graduates is expected to increase by about 20 percent. As pointed out previously, the students, on applying for entrance to a VTUZ, must specify a particular specialty in presenting their applications. The prospective students are required by law to present the original of their papers, including the certificate of graduation from a 10-year school, along with their application. This prevents the student from making multiple application. Only the very brightest students will apply for admission to the institutions with the highest rating and only the select few will apply for the specialties within those institutions which have the highest popular appeal. Thus there is an almost automatic selection of student quality in certain specialties which is forced by the system.

If a student thinks that his grades from a 10-year school, and his chances of passing the admission examinations at, for example, Lensoviet Technical Institute are not so good, he will apply to an institution where he hopes the competition will be less severe, usually at some institution a distance from Leningrad or Moscow.

Table 1 gives a list of 29 different specialties that were identified in the field of chemical engineering alone. Throughout the various chemical engineering specialties about 35 percent of the students are women. However, within the specialties there will be certain places where women form the majority of the students. This was observed in the specialty of Technology of the Milk Industry at the Frunze Polytechnic Institute where 65 to 70 percent of the students were women; whereas in the specialty in Silicates, including the sub-specialty in cement, there was 65 to 70 percent men students. Once a student has selected his specialty he must stay with that specialty and later obtain a position working in that industry. It is very unusual to have any voluntary shifts. From time to time changes in the Plan may cause a change in the number of graduates needed in certain areas. Then the student is given a chance to shift. A specific example of this shift was observed at Kuibyshev.

The student

In the Soviet Union the Plan provides that the normal student will go to work in industry immediately fol-

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Continued

lowing graduation from the 10-year school. After a year or two in industry he will then take examinations for entrance into a particular specialty at an institution of higher learning. It is the hope of the government that 80 percent of the students will follow this path and only the brightest 20 percent will go immediately from a 10-year school into the institutions of higher learing.

It is interesting to note that there is distinct opposition among the educators to the government policy of recommending one or two years in industry before continuation of the education of the student in the institution of higher learning. The actual facts are that in those schools visited by the Exchange Mission in Engineering Education, the percentage of those going into institutes of higher learning from industry ran from a high of 40 percent at one institution to a low of 25 percent at another institution. In other words, from 60 to 75 percent of the students entering the instiutions of higher learning are still going directly from the 10-year school to the institution of higher learning. The Government is making distinct overtures and taking steps to change this pattern and probably will succeed in increasing the percent that goes to industry from the 10-year schools before they enter the institutions of higher learning.

There seem to be several different identifiable reasons why the Government is so interested in getting the young men and women to enter industry immediately after graduation from a 10-year school. One of the reasons apparently is to close the widening breech between the worker on the one hand and the more educated engineer and scientist on the other hand. Another, and probably more significant factor at the present time, is the manpower squeeze caused by the low birth rate in the early 40's during World War II. As a result the present graduating classes from the 10-year schools are smaller in size than in previous years and thus not enough factory workers are being produced. Therefore there is greater need for getting more people into industry in order to meet the big production quotas of the five and seven year plans. It is anticipated that this manpower squeeze and small graduating classes will continue until about 1965. The birth rate in Russia did not start to climb until about 1947 or 1948. Since no official census has been taken in Russia, the actual manpower figures are only educated guesses, but the figures on students enrolled in the 10-year schools are available.

In order to enter an institution of higher learning, either a university or a technical institute, including the VTUZ's, the prospective student, as noted above, must make application to a particular specialty and a particular institution, submitting the originals of his diploma and other papers. Then he must take entrance examinations in five subjects: mathematics, physics, chemistry, the Russian language and a foreign language. The entrance examinations are common to all institutions and all specialties in the institutions in the USSR, but they are graded by the staff of the particular institution to which the student applies. Therefore, there may be some variation in grading standards. Each examination is graded on a basis of five—equivalent to A in the U.S.; four—B; three—C; two—D; and one—F. The total possible credits then for the five examinations would be 25 for a perfect score. At the institutions offering chemical engineering which were visited by the writer the cut-off score for entrance varied as follows: at Lensoviet Technical Institute and at the Mendeleyev Chemical Engineering Institute, it was between 22 and 23 out of 25; at the Kuibyshev Polytechnic Institute it was between 20 and 21, and at the Frunze Polytechnic Institute it was between 18 and 20. It is obvious therefore, that the competition for entrance into the institutions of higher learning is quite severe, and that there is a variation among the institutions.

In all of the institutions visited it was said that most of the failures occurred during the first year, and that the failure rate was about twice as great for those students who entered institutions of higher learning from industry as compared to those who came directly from a 10-year school. This explains, at least in part, the

Table 1. Chemical Engineering Specialties in Operation.

USSR—November 1958

Name of Specialty	Where Observed
1. Chemical Engineering Technology	L, M
2. Inorganic Substances Technology	L, M
3. Organic Substances Technology	L, M,
4. Rare and Disposers elements	N. O.
5. Silicates including subspecialties in cement, glass and ceramics	L, M
6. Petroleum and Gas	K, M
7. Solid Fuels	M
8. Dyes and Intermediate Products	N. O.
9. Pharmaceuticals and Perfumes	N. O.
10. Plastics	M, K
11. Varnishes and Paints	M
12. Rubber and Synthetic Rubber	K, L
13. Cinema and Photo materials	N. O.
14. Physical Chemical Technology	M, L
(a) Electrical Vacuum Industry Materials	M*
(b) Technology of Radioactive Elements	M*
(c) Technology of Separation and Use of Isotopes	M*
(d) Peaceful use of atomic energy	M*
15. Electrochemical Processes	M
16. Chemical Technology of Explosives	M
17. Chemical Kinetics and Combustion	N. O.
18. Technology of Wood Pulp and Paper	N. O.
19. Baking and Confectionary Processes	N. O.
20. Technology of Sugar Products	N. O.
21. Fermentation Processes	N. O.
22. Technology of Canning Industry	F
23. Technology of Meat Industry	F
24. Technology of Milk Industry	F
25. Animal and Vegetable Fats and Oils	N. O.
26. Chemical Technology of fiber Materials	N. O.
27. Technology of Artificial Fibers	N. O.
28. Technology of Artificial Leather	N. O.
29. **Mechanical Design of Chemical Machinery	L, M, K

Code
F Frunze Polytechnic
K Kuibyshev Polytechnic
L Lensoviet Technical Institute
M Mendeleyev Chemical Engineering Institute
N. O. Not observed

** Experimental 5½ yr. course.*

*** Given under chemical engineering faculty but considered a mechanical engineering specialty.*

opposition of the educators to the work interval between the 10-year school and the institutions of higher learning. The over-all graduation rate in five years from the institutions of higher learning is 85 percent of the entering class.

Practically all the students receive a subsidy in the form of a stipend which starts at 300 rubles a month in the first year, and goes up to 500 rubles a month in the fifth year of residence. Those students who get the equivalent of a 4 average (B) in their studies get a 25 percent bonus in their stipend in the following year. In addition, each VTUZ has a number of super scholarships for students who have the equivalent of a straight 5 (A) average. These students get an additional 25 percent above the B student. Apparently about six percent of the students make the straight 5 grade. This figure was verified by the fact that the budget in several institutions which had approximately 10,000 students showed 600 of these special scholarships available. In one institution the Director stated that he did not always fill his quota of these super scholarships.

The most noticeable difference between students in the VTUZ's and the students of the engineering schools in the United States is the greater concentration of the USSR students on their studies. The answer, apparently, is the extreme motivation in the USSR for a student to obtain a diploma. Without a diploma from an institution of higher learning it is virtually impossible for a person to rise above the grade of foreman in any industry in the country. Those good foremen who show promise and could be promoted above that grade are urged by their supervisors to either enroll at night school or a correspondence school. They are given time off from work to study, to take the examinations, and to attend certain laboratory courses as long as they progress well toward their diploma. The promotion does not come, however, until the diploma is achieved.

On the other hand, graduates of the VTUZ's are guaranteed a job at least the equivalent of foreman or better in an industry of their specialty immediately upon receipt of the diploma. As a matter of fact, the Minister of Education continues to have responsibility for the student for three years after he gets his diploma. During that period the Ministry of Education checks to see that the industry employs the student in his specialty and at a level commensurate with his edu-

continued

Snack bar at the Moscow Higher Technical Institute Named For Baumann shows typical students. It also shows the considerable proportion of women in an institution devoted 100 percent to engineering.

Entrance to main building at Baumann Institute. (L. to r.) Professor George Nickoliev, assistant director for research, and Professor K. P. Stanukind, head chair of applied mathematics.

. . . teaching at an institution of higher learning (in the USSR) is more attractive . . . than it is in almost any other part of the world.

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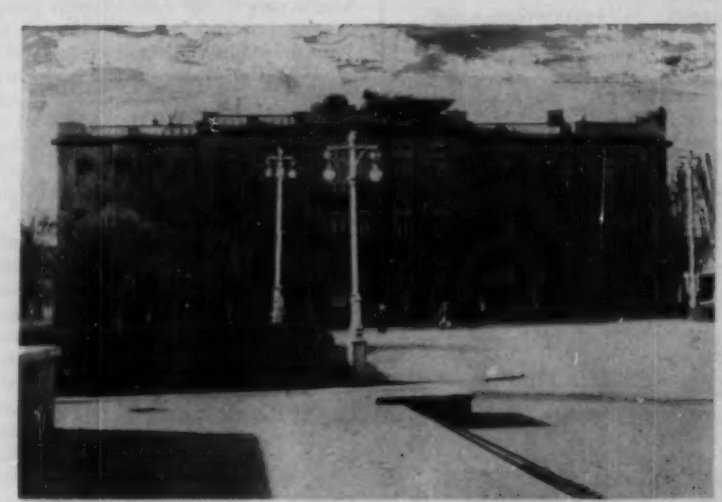
Continued

cation. After the three-year period, apparently, the students are on their own.

Another striking difference between the United States and the USSR is the proportion of women students and women employed in chemical engineering. (See the picture showing students at a snack bar.) In the fine chemical industries, and in the specialties leading to degrees in those areas, the proportion of women may run as high as 65 to 70 percent, whereas, in the heavy chemical industries, and the chemical engineering specialties leading to those industries, the proportion of women may drop as low as 15 percent. On the general average throughout the various chemical engineering specialties which this writer visited, the total number of women students seemed to run between 35 and 40 percent.



One of the buildings of the Polytechnic Institute of Tashkent, Uzbek S.S.R. This particular building houses the chemical engineering specialties.

The staff

The prestige of a Professor and Docent (associate professor) is very high in the USSR. Not only is the prestige high, but the salary paid ranks with the highest salaries paid. The base pay for a professor in a VTUZ or any other institution of higher learning, including the universities and the academies of science, is 5000 rubles a month throughout the USSR. In addition, if a professor selects the correct research program, as noted below, he may earn 2500 rubles a month in addition, making his total salary 7500 rubles a month. This compares with 750 to 850 rubles a month for a skilled technician in an industry, and compares to a salary of 5000 to 6500 rubles a month for a plant manager depending on the size of the industrial plant.

Any institution of higher learning can attract persons away from industry if it wishes. In order to receive an appointment as a professor the procedure is rather elaborate and given in detail in the final report (*1*) of the Exchange Mission on Engineering Education. The same is true for the docent grade. The professor must have a doctor's degree and the docent must have a Kandidate's degree. In special cases the VAK (The Higher Attestation Commission) and the Ministry of Education make exceptions for persons who have made distinguished records in industry which they may consider the equivalent of the Doctorate or the Kandidate's degree. However, it takes a plenary session of VAK to confer a professorial appointment and to make any exceptions to the general rules.

An individual institution may not appoint an individual to a professorial position unless he has received the docent or professorial title from the central authority at Moscow.

Since the salaries are uniform throughout the USSR, the older, more well-established VTUZ's in Moscow and Leningrad, because of their higher prestige, attract the most distinguished scholars in their particular fields. This is just as true for chemical engineering as for other areas. The newer and younger institutes, like the Frunze Polytechnic Institute, sometimes have more difficulty filling the postions and sometimes have docents acting in professorial positions. In some cases instructors who have not obtained the Kandidate's degree may be acting in docents' places. All of these persons are working toward their advanced degrees but have not yet attained them. The explanation given for this makeshift is a manpower shortage which it is said should be eased within the next 10 to 15 years.

The working hours and duties for the staff are also prescribed by the central authority. The normal work load for a professor is approximately 1,500 hours over a 10-month period, the other two months are considered vacation. Of these 1,500 hours every professor is expected to spend 500 to 600 hours on his various teaching duties, 500 to 600 hours on his research and the balance of his time on writing, consulting and editing as he sees fit. Every professor must lecture to some undergraduate course and likewise must engage in research.

The budget of the institution which is supplied by the Ministry of Education is insufficient to support the required research load. The institutions must contract for additional support for research with various industries and with the academies of science. It is for this type of research which the professors and docents receive the 50 percent addition on their salaries. Any professor or docent who is worth his salt is engaged in this type of research and gets the maximum salary.

In brief then, the faculty situation can be summed up by saying that teaching at an institution of higher learning is more attractive from a financial standpoint and a prestige standpoint than it is in almost any other part of the world.

1. Engineering Education Exchange Mission to the Soviet Union, *Journal of Engineering Education*: Vol. 49: No. 9, p. 889; May, 1959.

Part 2 of this report will consider specific curricula, will appear in September.

the operators report on SAFETY in air and ammonia plants

This third section of the exclusive CEP report on the recent informal roundtable session takes up such problems as tankage, repairs, and transportation of liquid air and ammonia.

CHAIRMAN WALTON: Last year Mr. Maune told us about failures of piston tail rods. It has led many of us to adopt additional safety devices.

deVRY, Hercules Powder: The safety record of ammonia-plant synthesis gas compressors has been good. However, there have been two major ammonia-plant accidents in recent years which were the direct result of compressor failure. In each case, a large quantity of synthesis gas escaped directly into the compressor house, resulting in explosion and fire, with heavy loss of life and property. These accidents, plus several others of lesser magnitude, emphasize the need for care. A piece of high-speed, reciprocating machinery, compressing a flammable gas mixture at high pressure and (usually) located in a closed building occupied by operating personnel, has all the ingredients for a major catastrophe, and therefore deserves serious consideration.

There are two common types of failures in which large amounts of gas can suddenly escape from the compressor: (1) the failure of connecting pipe or joints; (2) the breakage of a cylinder, cylinder head, or valve-chamber cover; (3) and a special case, the breakage and subsequent escape of the tail rod from a compressor cylinder (the cause of one of the two major accidents mentioned above).

Connecting pipe failures are usually the result of repeated stresses, caused by pulsation. This pulsation is not basically a vibration of the pipe, but of the gas column inside the pipe. The moving gas column is traversed by pressure waves, moving at the speed of sound and usually at a frequency corresponding to the speed of the compressor. Usually these pressure waves do not build up much amplitude and the resulting vibration is moderate and easily controlled. However, if the compressor piping happens to be of critical length, to allow the system to resonate at the compressor speed, the pressure wave will be reinforced and built up. The actual gas flow from a cylinder is irregular because of the changing piston speed at various stroke positions. This results in a number of harmonics which, if they match the resonant frequency of the piping system, can build up large pulsations, and cause trouble. Because of its complexity, the prediction, in the design stage, of the resonant frequency and resulting vibration amplitude of a piping system is extremely difficult.

A number of methods have been proposed but none give satisfactory results. We usually are faced with the problem of correcting a situation soon after the plant has started up. There are a number of ways to cure resonance troubles. The most direct is to change the natural frequency of the pipe by changing its length, or adding a stub pipe to detune the system. An orifice not only changes the natural frequency of the piping but also damps the pulsation wave. A volume chamber lowers the natural frequency and reduces the pulsation amplitude and resonance. An acoustic filter (pulsation dampener) which passes only waves below a given frequency, will cure the trouble if the frequency is set below that which causes the vibration.

Several basic design practices which should be included in any new system to avoid this trouble are:

1. Use adequately sized suction and discharge surge drums as recommended by the compressor builder.
2. Avoid closely sized interstage piping.
3. Avoid building bourdon tubes into piping layouts.
4. Use machine-mounted intercoolers whenever possible, they avoid connecting pipes.
5. Use long-radius ells in piping.
6. Avoid long, unsupported pipe runs.

One frequent cause of cylinder or head fracture is liquid carryover into the cylinders. Compressors are invariably provided with liquid separators ahead of each stage, with the possible exception of the first stage. However, if the process includes, for example, CO_2 removal between compression stages, it is quite possible to get liquid carry-over from one of the scrubbers which exceeds the holding capacity of the separator. Such systems should be provided with a large separator in the form of an empty vessel between the scrubbing system and the next compression stage. The vessel should be provided with a sight glass, blowdown, and a liquid-level alarm. In certain cases such a vessel should also be installed on the compressor suction line.

Sometimes condensate will carry over from an inner cooler separator. This usually can be traced back to failure of an operator to blow the system down to schedule. But sometimes it results from the use of excess oil, which emulsifies with the water to a mayonnaise-like mixture, difficult to purge from the drum. This is especially true at high pressures.

Where it is necessary to use a cylinder having a tail rod, such rods are ordinarily enclosed in a light steel case which serves to trap packing leakage and to prevent personnel injury. Should the rod break, for example, where it joins a piston, the broken rod will act as a free

piston and under the pressure differential be driven with great force against its enclosure, breaking out, followed by a heavy rush of gas. The remedy is to provide a tail-rod case heavy enough to withstand the impact force and also to provide a means of absorbing a portion of the shock load.

These factors are incorporated in a design where the normal packing flange is provided with elongated studs to which the flange of the tail-rod catcher is bolted. To help absorb the shock load, a plug of cushioning material is provided at the end of the catcher.

Walton

Wright

Bollen

One basic way to minimize the danger of fire and explosion in and around the compressor is to install it outdoors. Our most recent installation of a large-size compressor was outdoors.

MAUNE, Mississippi River Chemical Co.: The accident at my plant was covered in *CEP* recently. A tail rod broke in a compressor. Apparently, cracks developed and originated in the ring groups. The problem has been solved by newly designed rods which have been operating about eight months with no apparent difficulty.

We experienced difficulty with our high-pressure cylinders. The synthesis gas compressors are four-stage machines, compressing hydrogen and nitrogen from 290 to 9000 lb./sq. in. A crack developed in the main cylinder body. There were three such failures during the past year, fortunately, without serious accidents, because the compressors were taken down in time. Although we and the compressor manufacturer are still working on the problem, to date we don't know what is causing this difficulty.

We have been plagued with vibrations on the synthesis gas compressors, to the extent that the whole unit would move several mills on the foundation. We also experienced breaking of pipes in the piping system. Some vibrations in the piping system were eliminated by redesigning the piping layout, and placing bottles nearer the compressor cylinders. Some were traced back to the engine firing, which indicated that the speed varied 5 to 10 rev./min. Replacing several ignition coils eliminated this problem. Now, the units are doing very well. Our biggest problem is still the high-pressure cylinder breakage.

WRIGHT, Standard Oil (Indiana): At the Calumet Nitrogen Products plant, a rod on one of the synthesis gas compressors failed. Fortunately, the failure was detected when the crack had progressed only three quarters through the rod. The breakage was indicated by leakage of hydrogen down a longitudinal hole in the rod. On checking the rod, we found the steel was not of the proper composition for nitriding.

Another experience was failure of interstage piping around the synthesis gas compressors, due to vibration. The bracing consisted of wood blocking with tie-down straps over the piping. As the wood blocking worked loose, the strap bolts broke and allowed excessive motion. The bolting and blocking were improved, and no more failures have been experienced.

BOLLEN, Dow (Canada): We have had three failures on the third and final stage of our synthesis gas compressor. The rod in question has a suction valve contained in the piston itself. The piston rod has two lands which support the piston at each end with an undercut section of rod between the two lands. On the first occasion the break occurred at the thread root at the extreme end of the piston rod which holds the suction valve to the piston. This rod break was believed caused by excessive tightening of the nut holding the suction valve to the piston rod. Subsequent tightening operations were made with a torque wrench, in accordance with manufacturer's recommendations.

A few months later, the rod failed at the same point as the first break. Careful examination of the break and a review of design stress calculations for the rod indicated that the probable cause of failure was metal fatigue, with the main stress point at the last thread root. To overcome this problem, the manufacturer redesigned the rod and reduced the diameter of the undercut section of the rod from 0.872 to 0.6875 in., to keep the minimum cross-section area of the "business" end of the rod less than the root area of the 1-in. threaded section. This was to keep the operating stresses in the threaded section below those in the undercut section and so improve the fatigue life of the rod.

The third rod failure occurred at the undercut section of the rod and it appeared that the weak point had just been transferred from one place to another. However, examination of this fracture showed that it was not a fatigue failure. Something had jammed between the piston and the cylinder wall causing elongation of the undercut section to the point where the rod broke.

In each of these rod failures, no gas was released into the building and the breakage was confined to the cylinder, piston, valves, and cylinder line.

WHITE, San Jacinto Chemical: We have cracked some 15,000-lb. cylinders. Our supplier has come up with a pretty good answer—which is stress corrosion. We had never paid too much attention to our spare cylinders. When in storage, their outsides would get a little bit rusty and, frankly, the insides too.

WAIBEL, Ingersoll-Rand: It is interesting to note that the cylinder and the cylinder heads that failed at San Jacinto had been in operation at Louisiana-Missouri all during the war. Because the cylinders had been in operation for years, the source of the corrosion is difficult to pin down, but the evidence was there. There is no doubt that stress-corrosion fatigue was the main reason for the failure of the cylinders and heads. We recommended that they heat the inlet gas, and we made a major design change which should solve the problem.

CHAIRMAN WALTON: What was the nature of the atmosphere? Was it wet ammonia?

WHITE, San Jacinto Chemical: It was synthesis gas, nitrogen-hydrogen, and probably traces of NO, but we never found it.

deVRY, Hercules Powder: I can bear out that those cylinders had been in use a long time. They had hundreds of millions of reversals, and it actually is not too surprising that some of them did crack. We had the same experience on sister compressors at other plants; it wasn't a bad problem, but we did help it by heating the gas coming into the cylinder, to keep in the vapor phase little droplets of water that can cause what we think are points of stress corrosion.

CHAIRMAN WALTON: Certainly you always have to be alert to small details such as the need for fillets instead of sharp corners and shoulders. The more you hear about metal problems, the more you realize that the metallurgist is a man who still has a great deal to do with our problems with engines, and piping, and so on.

HENDERSON, Collier Carbon & Chemical: We had a synthesis gas compressor experience. The compressor started knocking severely and was shut down and examined. The third stage of the compressor operates at a discharge pressure of about 3,000 lb./sq. in. gauge. The piston is held onto the rod by a hex nut, threaded onto the rod, and recessed into the piston. The nut is about 4-in. diam. and 4 in. long. The threaded portion of the rod containing the nut had broken off, and in the space of 1/5 sec., it had come out of the recess, reversed itself, and had gone back into the hole. Fortunately it had jammed itself with only a small portion of the broken end of the rod extending past the end of the piston.

WHITE, San Jacinto: We have had trouble with breaking tail rods and overheating packings. At high pressures packing does not flex up and down at all, but just becomes a very tight bushing. We had made the mistake of not starting our circulation until we needed it, usually between 4,000 to 5,000 lb. of pressure after reduction. If the circulator is started at that time, the packing can't align itself in its natural reciprocating motion. But if we start the circulator at zero pressure, and let it run until somewhere around 1,000-lb. pressure, then it can be shut down, and as long as we have pressure on the circulator, we can start any time. That might be one lead on tail-rod breakage.

CONKLIN, Du Pont: For years we have always enclosed our compressors in buildings. Presently, we are building an anhydrous ammonia plant near Atlantic Refining's installation. This new plant is along the river where winters are not too severe, but extremely damp with much rain and some snow. Underscoring Dr. de Vry's remarks concerning outdoor installations, we did believe it necessary to put a wall on the river side of the building to keep out the wind-driven spray. We also added a roof with a full length ridge ventilator. The other three sides of the building are completely open. The operating floor, which is 7 ft. above grade, is of subway grating construction. All of this makes for a rather cool place to work. However, we believe that all possibilities of forming flammable gas pockets within the building have been eliminated. Any additional reduction in weather protection will not make the installation less hazardous, but will increase operator discomfort to an undesirable level.

Are there any here who can relate knowledge or experience they may have concerning the approach that the Southwestern Research Institute has made in investigating compressor pulsations, piping vibrations, and the like by means of their direct-simulation analog computer?

WAIBEL, Ingersoll Rand: A conference was held in San Antonio earlier this month, financed mainly by all of the major compressor manufacturers and members of the Southern Gas Association. Southwestern has obtained some interesting data and information which will be available in the near future.

CHAIRMAN WALTON: We've attempted to measure vibration with instruments to help us control it, without much success. We have varying rates in our plant because our hydrogen supply is variable. Piping vibration is a continuous problem. We have a boiler-maker who spends almost full time, five days a week, on compressor piping vibration problems, making new braces and tightening up existing ones.

deVRY, Hercules: We found we could do a good bracing job if we planned the piping in the compressor foundation to allow heavy anchor bolts to be buried in the compressor foundation. Such anchors pin the pipes close to the cylinders. It just isn't enough to put piers down. A small pier just breaks loose from its base in a short time. Wherever possible, we provide the anchors in the compressor foundation and wherever possible, we use machine-mounted intercoolers, because they eliminate the pipe run to and from the cylinders.

WHITE, San Jacinto: We have used wood bracing several times. It seems to us that wood has just enough give in it so the anchor bolts don't tear out quickly, and to some exent, it helps absorb vibrations. We use 10 in. x 10 in. timbers.

CHAIRMAN WALTON: We used wood many times for emergency, but we have never left it in for any length of time. It is interesting that you have snubbers, such as Burgess-Manning's, which help but are not by any means the entire answer. On our most recent compressor installation we had such snubbers which did reduce, but not cure, our problem.

During the past year we had a 2-in. connection break about 75 ft. from a compressor. It was a safety valve off the main line which we thought would never break because of fatigue; it cracked. There was no fire, but it caused a shutdown. That connection was replaced with a Taylor forge-type welding nozzle and brace. We originally thought we had to use these heavy weld nozzles in the piping (only) between the compressor and the first major piece of equipment. We have since had failures beyond that point and are expanding our use of heavy welding neck nozzles for such connections.

In every case we had insisted on having flanged valves as the first valve on a small piping connection, from a large line or vessel. These valves, in small piping sizes ¾, ⅝, or 1 in. are fairly heavy. In the past year, however, we changed to welding a ¾ in. stainless steel Pratt & Cady-type barstock valve into a flange. That has been satisfactory and there's less weight to vibrate.

deVRY, Hercules: Our practice on small gauge connections and sample points on high-pressure lines was to make the connection and then lead the tubing along the main pipe down to some independent point. Of all the piping failures in compressors (high and intermediate pressures), fully 50% of them have come from breakage of cantilevered valve connections at sample points.

CHAIRMAN WALTON: Use of piston-pipe checks has helped in our vibration problems. This is a floating-type check without the vibration that's caused by the swinging check slamming closed after each stroke of the compressor. On equipment procedures for preventing liquid carry-over, one thing which is too easy to do, is to place great dependence on safety devices, liquid-level controls, level alarms, and so on. Routine checks of level alarms and such, by the operators are, I think, quite necessary—something requiring vigilance.

Waibel White Henderson

High pressure equipment

CHAIRMAN WALTON: If a crack develops in a connection off the synthesis loop, what is the practice of handling leaks? Our practice is to shut down and depressurize. If the leak flames, we don't put it out until the pressure has been reduced, feeling that a lot of synthesis gas around the place is more of a hazard than a small fire at the point of the leak, for a short time. Of course, we worry about a leak causing too rapid a drop in pressure, and its effect on the catalyst.

In the history of line failures, has there been any failure in high-pressure synthesis gas systems other than small connections to gauges and sample connections?

WILEY, Standard (Indiana): When our plant was built, the installers forced some of our synthesis piping to make it fit. Then we had some failures. We had to take a lot of that piping down and heat it for stress relief to put it back as it should have been. We also had trouble with the interstage piping on our compressors because of poor weld penetration—some as little as 25%. We just completed a turnaround where we had to redo much of this welding.

deVRY, Hercules: We had success with lens joints on our high-pressure piping. We have used copper gaskets between tongue-and-groove-type high-pressure flanges at 1,000 atm. In our recent plants, we have gone over completely to lens joints, as we find they're more easily lined up, stay lined up better, and seem to contain the gas better.

CHAIRMAN WALTON: I can duplicate that experience. We have lens-type joints on our high-pressure vessels which have been extremely satisfactory. Our plant operates at about 4,000-lb. pressure and most of the piping joints are ring-type joints, which have also been satisfactory at that pressure.

WHITE, San Jacinto: Where you have a high-pressure leak, has anyone else noticed that sometimes some finely reduced catalyst (which is usually in your lines) will blow out through the leak and light off the leaking gas. It's a hazard which we now realize.

CHAIRMAN WALTON: That's an ever-present danger. A question was raised as to liquid-level devices in normal and subzero services in high-pressure equipment. Does anyone have problems to bring up? In our high-pressure separator, we have a Fisher-Leveltrol which has been satisfactory. There's always danger that you'll collapse the float, but if its been properly designed, it will be all right.

STOCKBRIDGE, Southern Nitrogen: We have some serious problems with level controls on our high-pressure separators. Would you mind mentioning the ones you use?

CHAIRMAN WALTON: Fisher-Leveltrol. The specifications given to the Fisher people were the operating conditions of the unit. Other than that, I don't believe there's anything special about it.

continued

We have a spare float for it on the chance that it might collapse, but have never had to use it.

STOCKBRIDGE, Southern Nitrogen: Is it mounted in the vessel, or external to the vessel?

CHAIRMAN WALTON: It's external. One problem that came up with a Magnetrol high-level alarm we installed external to that vessel was that the high-pressure separator in our plant operates at 20°, and in warmer weather, the heat leak into the lower leg to the Magnetrol was sufficient to cause boiling. This made the operation of the alarm rather erratic. It gave peculiar readings. Insulation of the leg corrected the difficulty. The top leg should be of greater diameter than the bottom, because there'll always be some heat leak and evaporation, and if the diameter of the top leg is restricting, it can give a false level.

KELM, Grace Chemical: For a level indicator in the high-pressure separators, we use a DP cell with a purge gas into the dip tube. Of course, the difference in the purge pressure and the vessel vapor pressure represents the level. This is not a controller; it is simply a recorder. To my knowledge we have had no instrument failure up to this time.

Tankage and spheres

KING, Sohio Chemical Co: So far we've heard about the troubles of ammonia manufacture. Of course, there must be good procedures for handling the finished product.

Monitoring vapor space for explosive mixtures occurs when dealing with small amounts of ammonia in air. It occurs more frequently in the user's plant than in an ammonia plant. There are two recorded instances: a Canadian brewery, where small amounts of ammonia in air caused a violent explosion; and a Texas food processing plant, where leakage of an ammonia refrigeration system caused a buildup of ammonia in air, resulting in an explosion. At Sohio, we try to keep equipment in operation for long periods, minimizing this problem.

Water-filling of storage vessels and blending drums and subsequent displacement of the water by gas is good practice for initial startup. In normal operation, where small amounts of air accumulate, an enclosed system can be vented to the atmosphere through an absorber or to a pressure-maintenance system. Normally, small vessels are removed from service by flooding with water after opening to the atmosphere.

Maintaining pressure on storage equipment and relief systems is another problem. To control pressure, Sohio uses vapor recovery systems to an absorber, or to a compression and liquefaction system. The liquid receiver of the vapor recovery system is continuously vented to an absorber system, which recovers any ammonia included in the vent. The vent consists of noncondensables, particularly hydrogen. The absorber system may serve as storage areas, loading racks, blending areas, or processing areas. Ammonia is continuously absorbed in steam condensate and may be sold as aqua-ammonia.

Relief systems on ammonia storage generally blow to the atmosphere where possible. As they age, relief systems must be brought under closer surveillance, and may require changing. Inspection on older storage vessels should be more intense, since stresses, corrosion, hardening, decarbonization, and a variety of things can occur. In a normal situation, a pilot-operated relief may be used.

In cold storage, failures can result from use of improperly processed materials. Cold forms have a high strength and are hard, hot forms are ductile. When shapes are welded together, notch formation can weaken joints. The same thing can occur in storage vessels; a notch can lead to cracking. In pressure-testing these vessels, the temperature should be carefully controlled. Failures can occur at low temperatures even in relatively low-pressure tests.

WHITE, San Jacinto Chem. Co.: One point worries me: putting water into a vessel containing ammonia. There might be some misunderstanding — certainly you'd never want to do that. Several vessels have been collapsed that way. One should always purge the ammonia out before adding water.

CHAIRMAN WALTON: Yes, I saw a tank car "pulled in."

ANONYMOUS: When we put our ammonia spheres into service, we did a lot of soul-searching before we finally said, "Well, we'll put the ammonia in the top and when we get ammonia out the bottom, it's there." I'm wondering just how much of a hazard we've been experiencing.

WRIGHT, Standard Oil Co. (Ind.): On the decision to use this method, the ammonia storage vessels have bottom connections of fair size available. A three-inch line was run from one of these nozzles to a location well away from the vessel, and a flame arrester was installed at the end of the line. Ammonia vapor was introduced at the top of the vessel at a very low rate so that, at most, there would be a very thin interface of flammable mixture.

Data on detonation propagation were examined to assure ourselves that, even if combustion occurred in this thin interface mixture, no damage could result to the vessel. We kept analyzing for ammonia at the base of the vessel and, as soon as it arrived, the vessel was buttoned up. There was practically no air left in the vessel and the residual amount could be safely eliminated through the storage refrigeration system.

CHAIRMAN WALTON: When we prepared our spheres for use the first time, we purged them out with nitrogen and pressured them up to about 20 lb. of nitrogen, released it, pressured again and released, and continued until the oxygen concentration was down to about 6%. Any cars sent to the repair shop are purged with nitrogen until no odor of ammonia is left in the car. And any cars that come in new, whose previous contents are unknown, are purged out with nitrogen. We use nitrogen strictly for that purpose.

We have monitored the spheres a number of times for explosive mixtures and have never found any. We find small (expected) amounts of hydrogen but by consistent use of nitrogen purge we haven't had any difficulties with explosive mixtures. To keep sphere pressures down, because a small amount of inerts always creep in, we maintain a continual bleed, which goes to the aqua-ammonia manufacturing system.

MARTIN, Spencer Chem. Co.: We

Wiley

Conklin

Stockbridge

piped nitrogen to the spheres, which we didn't do originally. We got scared at a safety meeting after learning about static discharges. We used to empty the spheres, then stick a fire hose in the top and let the spray absorb the ammonia vapors. The speaker described some accidents which made us realize that what we were doing could lead to a static discharge. So we pipe nitrogen to the spheres. I think it has taken care of the whole problem.

CHAIRMAN WALTON: Nitrogen is so inert, I recommend its use to any one not using it.

SWOPE, Southern Oxygen Co.: We use nitrogen as a purge gas on hydrogen gasometers and storage vessels as well as acetylene, and other flammable gas containers.

I would like to discuss statio electricity. A fire was described, which occurred when someone ran nitrogen into a void space in the top of a cold box through rubber hoses. I'd like to ask the gentleman, if he's present, whether those rubber hoses had any metallic fittings at the free end.

ANONYMOUS: Those were typical air hoses with metal Chicago fittings on the end. The fitttings were not touching the vessel.

SWOPE, Southern Oxygen: If they had been grounded or banded you might not have had the fire. To cite an example of static buildup: we had a line carrying nitrogen which we were using as a drying medium and discharging to the atmosphere through a rubber hose. To build a slight back-pressure on the system, we inserted a small metal ferrule in the end of the rubber hose. The hose extended through the building wall and the ferrule was approximately 6 to 8 in. outside the wall. We found sparks jumping the 6 or 8 in. from the metal ferrule in the end of the hose to the metal surface

of the building. There was nothing but nitrogen flowing through the line, at low pressure but at fairly high velocity. The explanation, as I understand it, is that a static potential will build up between two conducting media separated by an insulating medium when a fluid flows from one conductor to the other. Such is the case with a metal fitting on each end.

LARKIN, Monsanto: We use a different method. Our problem has been to purge air out of storage tanks used for hydrogen and nitrogen mixtures. We fill the vessel completely with water and then displace the water with nitrogen.

CHAIRMAN WALTON: We didn't use water because we were trying to keep the ammonia anhydrous; and actually the water left in would not have amounted to much, so we were probably being more careful than necessary.

KELLEY, Standard Oil (Calif.): Our experience in commissioning spheres was almost identical with yours. We pressured with nitrogen, 15 lb. or so, and depressured repeatedly down to about 5% oxygen; then put ammonia vapor in the top. It was interesting to note in analyzing the gas coming out at the bottom, that when the interface hit, we went from about 10% ammonia to better than 80%, rather quickly.

CULP, Grace Chemical: I would like to ask about monitoring the vapor space in aqua storage. We have 5,000,000-gal. tanks for storing 25% aqua. They are uninsulated and breathe heavily during the day and night. We have considered piping nitrogen to them, but to offset the breathing effect, a ten-inch line is necessary. We wonder if anyone has had a successful experience in monitoring this vapor space on a more-or-less continuous basis?

SIMMS, Phillips Chem. Co.: We have 150,000- and 323,000-gal. aqua tanks in which we store anything from 25% to say, 42% aqua. I agree with Mr. Culp that he can get an explosive mixture more readily in an aqua tank than in anhydrous spheres. At about 44°, the 25% aqua, assuming equilibrium conditions, is explosive. At a higher concentration, it may not get explosive until near 0°. In our installations we maintain a natural gas blanket, or use vapor from spheres, for pressure maintenance. If you have it available, your purge gas from synthesis can be used since it is a waste gas. We maintain a constant pressure of between ¼- and ⅜-in. of water, and breathing out is handled through, essentially, a vacuum absorber for ammonia recovery. It's been successful so far, but we shudder sometimes when we see all these other tanks around the country holding 25% aqua, and everybody thinks they're perfectly safe.

ANONYMOUS: May I ask what you do with the tail gas off the absorption of the vapors?

SIMMS, Phillips Chem.: If it is the purge gas from synthesis, of course we just discharge it into air because normally you would handle your purge gas for ammonia recovery through an absorber anyway. We merely take off what we need for pressure maintenance, bring it back to an absorber, and discharge it there. If it's natural gas, fortunately we're a natural gas producer—it is a loss.

CHAIRMAN WALTON: The "book" says the ignition temperature is 1200° for an explosion of ammonia in air, so people don't worry about it, but maybe we should.

There is some difficulty with corrosion of field tanks of ammonia in agricultural service and the conclusion is that our corrosion problems were confined to the cold formed shapes. We have examined our spheres, after three years' service, by magnaflux and visual examination, and have found no evidence of corrosion. The "orange peels" that went to make up the spheres were hot formed, of course.

Tank cars and trucks

HEDMAN, Shell Chemical: In introducing the subject (from the Compressed Gas Association's viewpoint) "Tank Cars and Trucks" in anhydrous ammonia service, I would like to review some recent developments relative to the increase in use, design, and regulations pertaining to these vessels. The increase in use of transport equipment, of course, goes hand in hand with the increase in the production of ammonia.

Equipment requirements, standards, and regulations, for industrial ammonia have remained more or less constant, while many developments have taken place in the agricultural ammonia industry due to the widespread use of anhydrous ammonia as a nitrogen fertilizer in dry farming areas.

Because of its rapid growth, the agricultural ammonia industry is, unfortunately, going through a trying period during which the lack of nationally recognized uniform standards plays a key part. The average dealer, or farmer, does not have the advantage of technical assistance, and is dependent upon the ammonia producer and the equipment manufacturers to furnish him with equipment which will give him maximum safety and a maximum return for his money. The customer has a right to expect equipment designed for the product he intends to handle and the job he expects to do, as well as protection through uniform standards.

The most widely used regulations have been those issued by the Interstate Commerce Commission applicable to the transportation of anhydrous ammonia in interstate service. Several other organizations such as the Compressed Gas Association, the National Safety Council, the Manufacturing Chemists Association, and the Agricultural Ammonia Institute have published recommendations for the storage, handling, shipment, and use of ammonia. Some 30 associations concerned with safety, compressed gas in general, and anhydrous ammonia in particular, are represented in the American Standards Association, K-61 Committee, presently developing American standards for storage and handling of anhydrous ammonia. We are sure that each of the controversial topics listed in the symposium's agenda will be discussed by the above representative group of experienced ammonia people and that we shall have a workable American standard in the near future.

*SAFETY ROUNDTABLE

Some of the most recent changes that have been made or are being recommended at this time in tank car and tank truck standards are:

1. The installation of more 2-in. valves for faster loading and unloading.
2. The recommendation which may make the installation of excess-flow check-valves mandatory.
3. The approval of uninsulated ICC Specification 112A400 tank cars, which will have relief valves set at 300 lb./sq. in. maximum, and a maximum filling density of 57%. However, during the months of November to March inclusive, a filling density of 58.8% may be used if these cars are loaded and shipped directly to the consumers for unloading. Storage in transit is prohibited.
4. A new proposal to allow insulated ICC Specification 105A300 tank cars to be filled to 58.8% from November through March is also being discussed.

Tank trucks for transporting anhydrous ammonia have been one of the controversial pieces of equipment in recent years due not only to the increase in use and dual service, but principally because of the 265 lb./sq. in. minimum design pressure required by the ICC Specification MC-330. Even though anhydrous ammonia has a higher vapor pressure than LPG, and would lower the present safety standards, many attempts have

Martin Kelm King

been made to change the regulations to allow ammonia to be shipped in existing 250 lb./sq. in. design pressure cargo vessels.

The most recent study made by CGA confirmed its earlier recommendations that ICC Specification 51 portable and ICC Specification MC-330 cargo vessels for anhydrous ammonia should be designed for a minimum working pressure of 265 lb./sq. in. gauge.

Velocity checks or excess-flow check valves have always been a controversial subject because of the difficulties they cause while unloading. These valves are necessary safety features and are designed to contain the product within the vessel in which they are installed in case the block valves on the vessel are sheared

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off. However, these valves are not designed to protect the material in the car or truck when a break occurs on the downstream side of an unloading system. These systems and storage tanks should be protected independently with supplementary check valves. Excess-flow check valves are necessary for safe operations even though they are touchy and some improvements in their design are in order.

Unfortunately, I don't have design data for the various types of excess-flow check valves. However, results of studies made of unloading rates by various methods vary considerably. The most accepted rate of maximum flow seems to be somewhere in the neighborhood of 50 gal./min. But tests indicate that with

Kelley Swope Simms

proper systems and operating techniques, there shouldn't be much difficulty in loading at 100 gal./min. In any case, one of the most important features, governing efficient unloading operations, is to train the operator to open valves in such a manner that sudden surges of ammonia will not shut excess-flow valves during initial startup operations.

Inspection and maintenance is a never-ending job, if done properly, to insure safe operations. Tank cars and trucks used interchangeably in LPG and ammonia service should be cleaned and inspected when entering ammonia service as well as when returning to LPG service. The following is a suggested cleaning procedure: 1. Depressurize tank car by pulling vapor to atmospheric pressure at plant. 2. Connect vapor valve to steam neutralizer. Vapors are mixed with steam and discharged to the atmosphere through a pipe extending into the air. 3. Connect steam to liquid valve and steam car until fumes disappear. 4. Dome cover plate with valves and piping is removed. All angle valves, safety valves, and other fittings are removed, inspected, and repaired. Packing glands are inspected, repacked if necessary and lubricated with grease suitable for the commodity for which the car is being cleaned. 5. Water is sprayed into the car at 150 lb./sq. in., then pumped out and the interior of the car dried with air. (If car has excessive scale, this is removed by sandblasting.) Tank walls are then wiped dry and cleaned with a vacuum cleaner to remove all fine lint or other foreign material. 6. Commodity stenciling must be changed on each side of the car to indicate the product for which the car has been cleaned. 7. Air is purged from the tank at the plant.

Air purging of tanks is very important. Air that is not removed from ammonia tanks prior to being filled with liquid ammonia will raise the total pressure in the tank over and above normal ammonia pressure. As an *extreme example*, if the tank is initially filled without a vapor return, this excess pressure will amount to approximately 83 lb./sq. in. for a tank filled to the 85% level. However, since a tank is generally filled with a vapor return, this excess pressure, for an initial fill, normally will amount to some 15-25 lb./sq. in. if no air is purged from the tank prior to the filling.

Many of the leaking relief valves on tank cars and trucks as well as portable and storage containers, are attributed to the lack of proper air purging practices. Recent investigations into the cause of stress corrosion crackings of ammonia containers indicate that improper air purging may be one of the causes. Every effort, therefore, should be made to eliminate air from ammonia systems.

Specifications for tank car and truck unloading as well as portable container filling hose, have finally reached a point where the industry has accepted a uniform standard. The basic specification for 1-in. and 2-in. tank car and truck unloading hose is wire-reinforced high-pressure hose with a maximum working pressure of 350 lb./sq. in. or greater, a minimum safety factor of 5 to 1, that is, a minimum burst of 1750 lb./sq. in. The cover stock is pin pricked black neoprene. The tube stock is ammonia-resistant GRS (or approved substitute). And the markings shall be permanently marked, that is, etched, cast, or impressed every five feet with the manufacturer's name or brand, the working pressure, year of manufacture, and Anhydrous Ammonia also indicated. The periodic test of hose assemblies, however, is still a very controversial subject. Several states have regulations requiring periodic hose tests, but there is no standard to guide them. The test pressure for new units is generally twice the maximum working pressure and retest pressures vary from ⅔ of the maximum working pressure of the hose to 1000 lb./sq. in.

COCHRANE, Sun Oil Co.: Testing of the loading hoses has been something we've always been concerned about. I would be interested in hearing what other people do, what kind of inspections they have, and how often.

deVRY, Hercules: We don't test them; just change them once a year.

I'd like some comment on this question of quick coupling on the ends of the hoses. We have used what looks like a half union. It's set up for a quick-coupling job. I don't know whether it's going to be adopted as a standard, but we see nothing unsafe about it.

WHITE, San Jacinto: We have standardized on a Weco-type coupling and several producers in our area have also adopted this coupling. It's fairly quick coupling but safe and practical.

CHAIRMAN WALTON: We also use it. It's a coarse-threaded union. We tried a number of the quick-coupling devices on the market and gave up on them. We were afraid of them. They stuck at times, and there were too many features that frightened us.

WHITE, San Jacinto: We tried to find a rubber that will take the cold temperatures you get when you take the pressure off these hoses, because each time you finish loading the truck and relieve the pressure, it gets very cold. We found that quite a few of the so-called ammonia hoses would crack. We do specify that our hoses will not crack, and actually test them. We change them once a year and use those removed for low pressure aqua service around the plant.

CULP, Grace Chemical: We, too, have found that hoses cracked from cold ammonia when disconnected. As a result we have standardized on hydrostatic testing of hoses once a month. I'm not sure of the pressure, but I believe it's 400 lb./sq. in.

DAVIS, Mississippi River: LPG hose operates at about the same pressure as ammonia-loading hose. I remember one plant in which a hose burst. There was an immediate clamor for hydrostatic tests. About 15 hoses were tested at 275 lb./sq. in.—about the maximum allowable working pressure. In no time new leaks began to appear. After some discussion it was decided that all high pressure propane hose would be changed at the end of a year, the old hose to be put in low pressure LPG service.

An inspection of ruptured hoses sometimes revealed the hose connections had been improperly inserted and had injured the hose tube. With most of the small leaks, the outer fabric would swell up and look very dangerous. "Pinholing" of the outer fabric was the solution for this.

MUZZY, Chemstrand: We had four rubber hose failures as we were starting up our ammonia handling facilities. These were ruptures, not cracking failures. Ammonia evidently penetrated the inner layers of the hose structure to collect near the outer surface. The higher temperature there caused a bubble to form and burst the hose covering. We solved our problem, not by changing hoses every year, but by changing to flexible stainlesss steel hoses which have caused us no trouble to date.

CHAIRMAN WALTON: The initial hoses we had developed bubbles also. We are now using U. S. Rubber style P-7130 which has proved satisfactory (no failures, leaks, or bubbles). It meets the standards Mr. Hedman mentioned. It has a wire-braid reinforcement with a neoprene cover that's pinpricked so that if leakage develops from the inner tube it'll show up quickly. Every six months we test at twice working pressure. Usually when the jacket starts to show signs of wear from abrasion against car domes or such, we retire it to aqua service. The company we lease our cars from inspects safety valves every five years, tanks every ten years, and never inspects velocity checks unless the customer asks them to, or somebody reports something wrong with them. The

latter is a rotameter-type design with a floating plug.

STOCKBRIDGE, Southern Nitrogen: I wonder how often anyone here inspects velocity checks in his own cars?

CHAIRMAN WALTON: To see if they're dirty or stuck?

HEDMAN, Shell Chemical: That's right. With the rotameter type, there's not much you can do except to see that they are clean, free and properly machined in the first place. We do this as a regular routine. We inspect and/or overhaul all the fittings in the dome.

CHAIRMAN WALTON: Does Shell Chemical inspect theirs regularly?

HEDMAN, Shell Chemical: That's right.

CHAIRMAN WALTON: How often? Every five years?

HEDMAN, Shell Chemical: Of course the relief valves have to be tested every five years by ICC Regulations. The cars go into the shop for full overhaul of fittings at that time. We've had considerable difficulty in the interchange service from LPG to ammonia and also from ammonia to LPG, so it has become necessary for us to run those tank cars through the shops for cleaning prior to customer service. At that time we inspect and/or overhaul all valves, but we do not have a set period under five years.

CHAIRMAN WALTON: I notice in Mr. Hedman's presentation that the Compressed Gas Association is apparently going to recommend complete cleaning of cars in shifting from LPG to ammonia. Am I correct in that, Mr. Hedman? The cars are put into the shops and cleaned?

HEDMAN, Shell Chemical: No,—that has been discussed from time to time in the CGA, but it was one of Shell's recommendations that it be done.

CHAIRMAN WALTON: We have taken some cars which have been in LPG service and purged them with nitrogen until free of hydrocarbons and put them into ammonia service without internal inspection. Has anyone else done that, or are we alone?

WHITE, San Jacinto: We had done that, especially in hauling on trucks, because very often they want to haul a truck one way with LPG and the other way with anhydrous ammonia. We had quite a fight on our hands to insist that they even purge them out, because the truckers say most people don't worry about that.

That brings up one other point while I'm up, if I may. Has there been any consideration given to differences in specs for tank trucks which use the tank itself as a frame for the truck? I've always worried about the extra stress due to rough roads, putting additional load on the tank, in addition to the internal pressure of a load of ammonia. I've often wondered whether there's additional strength designed into the tanks for this extra load.

HEDMAN, Shell Chemical: I don't know whether I can answer this question adequately, but I believe the required structural characteristics are taken care of in the original design to adequately withstand the stresses thereby imposed, in addition to those covered by "the Code." (For further reference, see Para. 78, 336-4 (C), ICC Regulations.)

Preparation for repairs

MARTIN, Spencer Chemical: One of our workers, working on an oxygen line from below, which had been depressurized but not purged, suddenly found a lively fire burning around his neck, ears, and face. He knocked off his mask and extinguished the fire easily, suffering only minor burns and the loss of his shirt collar. Cool oxygen gas from the pipe opening had flowed down over his head and shoulders, saturating his shirt. A welding spark, which would ordinarily have done no more than burn a hole in his shirt, set it afire, and it burned intensely until the supply of free oxygen was exhausted. This, of course, represents insufficient preparation for repairs, but who would have foreseen that accident? The job was safely finished with a small nitrogen purge going through the line. So much for the wrong way!

In Spencer's organization, the primary responsibility for the safe preparation of equipment to be repaired lies with the operating group. This group is most familiar with the process, and therefore, with its hazards. To be sure, maintenance personnel are expected to satisfy themselves that their undertaking is safe and that they observe the common safeguards for the type of work they're doing. Safety personnel are present in an advisory or consulting capacity and while they have the authority to stop a job, this is rarely done. In fact, operations and maintenance rarely disagree with safety section recommendations or suggestions. When this happens the matter is postponed until a solution can be reached which is satisfactory to everyone. Normally, the shift supervisor, or someone in that capacity, has the ultimate responsibility for seeing that the job is carried out safely. In some cases where the hazards justify it, the plant superintendent, the maintenance superintendent, and the highest of the local management may take a direct hand in the proceedings.

Clarity in explaining the exact nature and location of the job to be done is very important. This was illustrated when we had a maintenance crew start work on the wrong one of two identical exchangers. One had been prepared for them and was safe; the second was not. In fact, it contained hot MEA under pressure and this is the one on which they started to work. Fortunately, they were stopped before they got far enough to be in trouble.

Preparation for repair may be said to start with the writing of the maintenance work order. The writing is done by a supervisor as soon as he recognizes the need for maintenance. In addition to space for a proper job description, our maintenance work orders include several lines labelled "safety precautions." This space is not always sufficient to detail all the precautions necessary, but it is sufficient to act as a "flag" for the hazards involved and the writer is expected to list them. The work orders are reviewed by plant and maintenance superintendants before being issued to the people who will actually perform the work, so that several opportunities exist to recognize safety hazards and specify proper precautions. Shutdown work orders are further reviewed in a regular weekly production meeting. This meeting includes representatives of operations, maintenance, engineering, technical or laboratory, and safety. They are considered especially qualified to recognize hazards and to suggest precautions. Detailed, stepwise procedures are written for major, but infrequently accomplished, repair work. This not only expedites the work, but reduces the chance of error by men unfamiliar with the particular job. Many of these procedures are included in our operating manuals.

A daily operating bulletin, which contains production plans for the ensuing 24 hours, is also used to publish safety procedures relating to maintenance occurring during that period.

Occasionally exceptional circumstances will require consideration by the best qualified people in our company. A case in point is our procedure for purging and warming the nitrogen wash equipment. Due to an internal explosion and consequent damage which occurred in the wash tower in early days of operation, and which was never satisfactorily explained, the procedure now followed is very detailed and covers several pages.

The physical preparation often involves first depressuring or venting dangerous gases. (The liquids, such as caustic and MEA, can be taken care of by sufficient water flushing.) At our Vicksburg works, it is possible to burn all vent gases containing a high percentage of carbon monoxide. Other combustibles, such as hydrogen and natural gas, are not burned unless they are tied to the flare stack for convenience. However, they are normally vented at a high point. Regardless of whether the reason for purging the gases is due to their explosibility, toxicity or because they are capable of asphyxiation, purging methods are similar. Purging is preferably done with a once-through sweep—in one end of the pipe or vessel and out the other, at low pressure and high volume. This results in maximum displacement of objectionable gas by the gas being used for purging. Less desirable, but occasionally necessary, is purging by pressuring and depressuring through the same opening. If not done thoroughly, this procedure can leave pockets of toxic or combustible gases within the purged equipment.

Nitrogen from an air separation plant is a very satisfactory general purpose purge material, particularly when the equipment being purged is to be kept

* SAFETY ROUNDTABLE

* SAFETY ROUNDTABLE

dry. It's inertness makes it satisfactory for purging explosive and toxic gases. Where separation plant nitrogen is not available, a mixture of nitrogen and carbon dioxide (products of combustion) can be used in the same way, but this gas is rarely dry unless a special dryer is used. If the unit being purged is to be entered during maintenance, it's mandatory that the inert gas be followed by air providing sufficient oxygen for men within the vessel. This may seem fundamental, but in two separate instances we found it necessary to rescue people who had entered the nitrogen wash cold box and become unconscious because it was filled with nitrogen. In some cases steam may be used as a satisfactory purge material, in a shift converter, for instance. It is readily available and will not dry nor damage the catalyst, as would nitrogen. We have occasionally found it desirable to keep a small purge going through the equipment undergoing repair, when it's desirable to exclude air. Again, an example is the shift converter. In some circumstances, a vessel or line can be purged by filling it with water, or carbon dioxide if it's available.

Several analytical methods are available to determine whether purging is complete. The Davis Equipment Co. explosive detector is a satisfactory device in capable hands for determining the presence of an explosive gas mixture and the MSA sniff-type CO detector is convenient and accurate. Orsat analyses may be used to determine overall composition. A German "Drager" tester (Model 19/31 Multigas detector available from Safety Supply Co., 214 King Street East, Toronto 2, Ont., Canada), which we recently put into service, can detect a variety of hazardous gases and vapors, such as oxides of nitrogen, trichloroethylene, and CCl_4. If necessary, gas tests are conducted at frequent intervals while the work is in progress.

The use of blanks at flanges, and tags and locks on valves and switches is determined for each particular job. Blanks are always used to isolate a vessel which will be entered by personnel. They may also be used on piping where the hazard of burning or welding is great. Several times we've stopped someone in the act of breaking the flange on the pressure side of a closed valve to insert a blank. The use of chalk or soapstone marks is helpful in preventing this.

Valve tags are placed and signed by operating supervisors. They have detachable stubs which are also filled out and presented to the maintenance crew (I think these are fairly standard) after the tags are placed. These stubs are held by "maintenance" until the job is finished. No tag is to be removed until the stub has been returned to the operating supervisor who removes the tag, staples the stub to it, and forwards them to the area superintendent to show that this safety feature has been observed.

Electrical switches are usually locked open and tagged. Our electrical tags may be placed by electricians as well as by operating supervisors. This is the only exception to our rule that all safety work permits and tags will be placed and removed by operating supervisors.

When the area containing specific equipment has been properly prepared for maintenance, the operating supervisor fills out and signs the safety work permit in triplicate. This is a lengthy form which serves to state that the equipment is safe and as a check list to make sure certain things have not been forgotten. The original copy goes to the mechanic in charge of the work and is good for only one day. Other copies go to the area superintendant and the safety section. At this time the operating supervisor is expected to explain to maintenance personnel any hazards involved in the work, what precautions have been taken to protect them, and generally satisfy them that the area is safe. An operator or supervisor may be stationed in the immediate area while maintenance is being carried out to guard against unexpected hazards or unsafe practices. The operators are expected to feel and share the responsibility for safety and usually do all the preparatory work under the direction of their supervisor.

Cochrane

Hedman

Muzzy

Everyone concerned is challenged to be continuously alert for hazards unique in the particular area where work is being done. We also try not to forget the more common hazards, such as hot water, the absence of necessary oxygen for breathing, and high-pressure air. While we have a number of rules, they are to be considered for guidance only, and not as substitutes for careful thought on each job that's undertaken.

CHAIRMAN WALTON: One other thing I might mention in passing, is that we have had a couple of occasions where we had people working outside a vessel that had a nitrogen purge going through it, and up on a platform. The wind direction and velocity were such that it created an oxygen deficiency and a man got dizzy and nearly fell off the platform. So, you not only have to watch out inside vessels and inside cold boxes, but also outside if you have a nitrogen purge going through a vessel or a line at that point.

LARKIN, Monsanto: Our procedures for tank-entering and fire permits are similar to those at Spencer. I would like to elaborate a little on what Monsanto does.

The "Tank Entering Procedure" includes any equipment which may present the same hazards as a tank. A permit or form is used to make certain that all possible hazards are checked. Permits are usually initiated by the foreman or supervisor of the department where the work is to be done. It provides:

1. general description and location of equipment.
2. last product in tank before wash.
3. cleaning method used, or to be used, to prepare for entry.
4. precautions check list includes:
   - A. agitator motor leads disconnected in the starter or at motor. (No exceptions.)
   - B. all lines to and from vessel banked or disconnected.
   - C. a fresh air supply from a blower or from air bottles is discharged into the tank during the entire course of work.
   - D. watcher is located at opening to the equipment 100% of time work is in progress. (No exceptions.)
   - E. person entering must wear a wrist harness with life line attached, unless there is a bottom entry to the vessel.
5. if for any reason one of the aforementioned items is by-passed it requires approval at the superintendent level, or above. This approval is signed on the form.
6. special precautions to be taken other than those normally included on permit, such as protective equipment or clothing.
7. explosive gas testing result, time and by whom. (Required on all tanks by a trained tester.)
8. field inspection approval by foreman to ascertain if all precautions have been carried out.

We also require a fire permit before any spark-producing equipment can be used. The permit must be displayed on the job at all times, while the work is going on. The permit is generally initiated by the department foreman or supervisor where the work is to be performed, and approved at superintendent level, or higher. It includes:

1. general description of work to be performed, its location, dates, and times.
2. type of equipment or tools to be used.
3. all closed equipment and/or hazardous areas require gas testing for explosive atmosphere.
4. all special precautions required for the particular job are listed.
5. the area is checked for compliance to all precautions and signed for by the field inspector (normally the foreman). He signs the permit and witnesses the startup of the job.

These procedures do cause delays but have, for all practical purposes, completely eliminated accidents caused by unsafe tank conditions, and fires from careless sparks.

Part 4 of this exclusive report will appear in the September issue.

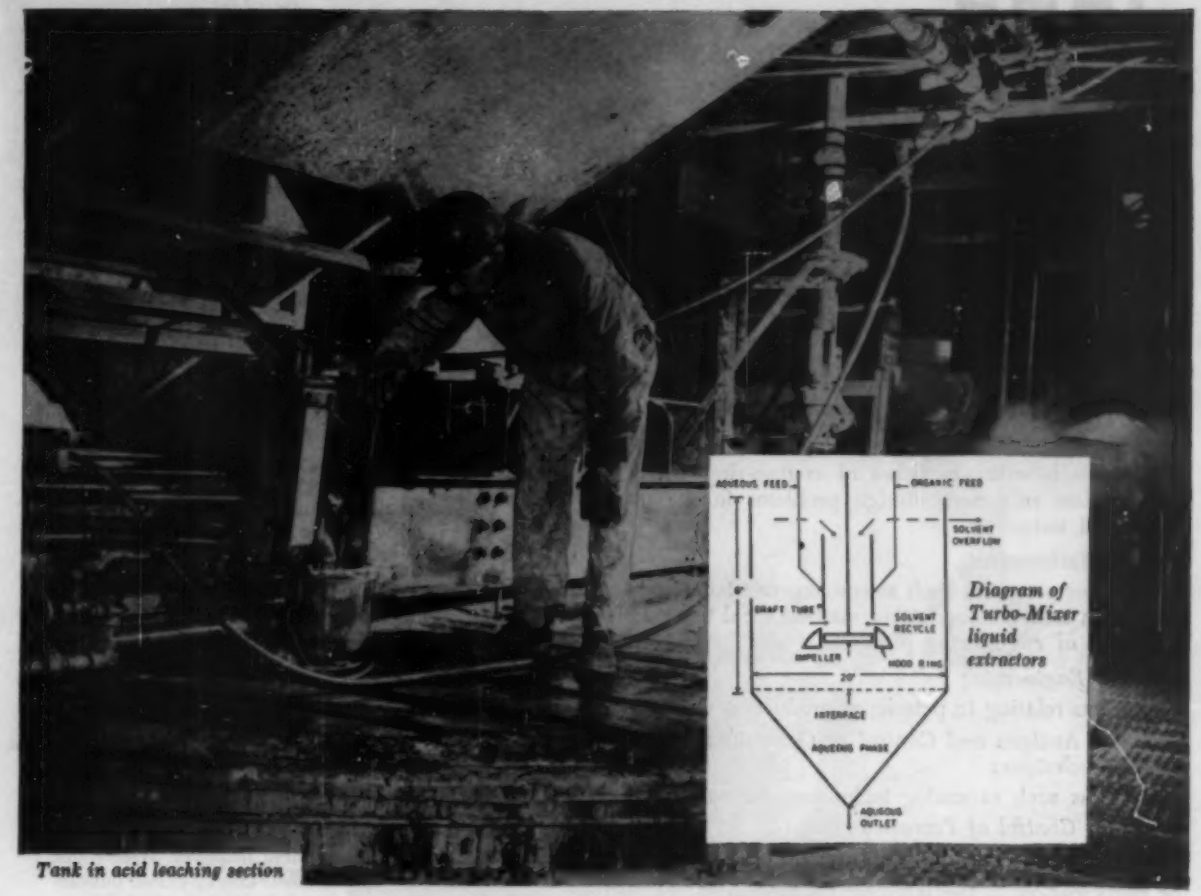

Diagram of Turbo-Mixer liquid extractors

Tank in acid leaching section

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CEP

COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts covering the following:

Chemical Engineering

The primary field of interest is chemical engineering computer programs of design and engineering nature.

Other Branches of Engineering

Programs in other branches of engineering are of interest as they relate to general design problems in the petroleum and chemical industries.

Applied Mathematics

Computer programs such as convergence techniques, differential equation solutions, and other mathematical treatments related to solution of engineering problems.

Reservoir Engineering

Programs relating to petroleum production engineering.

Statistical Analysis and Control of Operations
Analog Techniques

Programs such as analog techniques for surge vessel design.

Computer Control of Processes

Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o of A.I.Ch.E. in New York.

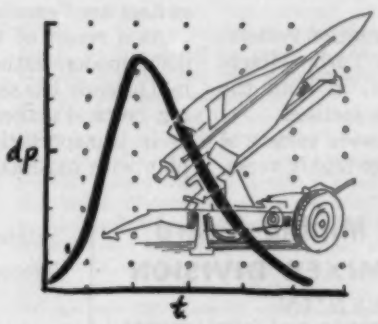
Specific impulse calculations (019)

C. Seafeldt, Jet Propulsion Laboratories, Pasadena, Calif., and C. D. Alstad, Dow Chemical, Midland, Mich.

Description: This program is being used to evaluate rocket fuels. The program calculates combustion chamber conditions and either or both the frozen equilibrium flow and the shifting equilibrium flow for exhaust conditions. Each solution gives the composition, temperature, enthalpy, entropy, moles of gaseous and condensed components. In addition, the frozen and shifting equilibrium solutions give the velocity and specific impulse. Any one of four systems may be calculated depending on the thermal data employed:

C, H, O, N, Cl, B	All give similar reaction products
C, H, O, N, F, B	
C, H, O, N, Cl, Al	
C, H, O, N, F, Al	

The number of combustion products are fixed (32) and cannot be varied.



The program is thus not general. The method has not been published but is somewhat similar to that given in "NACA Technical Report 1037".

Computer: Datatron 205, 4000 words storage, paper tape input and output. Optional equipment can include Datafile, card input and output, and floating point hardware. One simple machine modification is necessary which will not generally affect other programs.

Program language: Datatron 205 machine code.

Running time: From 3 minutes to 1 hour per solution depending on guesses employed.

Comments: Program has been successfully used to obtain more than 300 solutions. A very few of these did fail by overflow. These troubles may be eliminated by the time the program can be distributed.

Availability: The manual on this Program will be submitted for publication if there are sufficient requests to do so. The operating decks are available immediately. A more general program for the Burroughs 220 is in operation since July 30, 1959.

Generalized Flash Sub-Program (021)

Melvin A. Albright
Phillips Petroleum Company
Bartlesville, Oklahoma

Description: The sub-program calculates bubble-point temperatures, dew-point temperatures, and/or isothermal, adiabatic, or fractional flashes of multicomponent mixtures. With slight revisions, it will also calculate bubble-pressures and dew pressures. As given, the vaporization equilibrium constant (K) is used as a fifth order polynomial function of temperature, and the vapor and liquid enthalpies as cubic polynomial functions of temperature. This data treatment may easily be revised to conform to the user's desires.

Computer: IBM 709, 8K Core storage.

Program language: FORTRAN 709.

Running time: All options less than 0.5 seconds. (Datatron time was 0.5 to 8 seconds).

Comments: The sub-program converges rapidly from guesses which widely deviate from the solution. This sub-program can easily be adapted for use in any computer with command provisions for sub-programs.

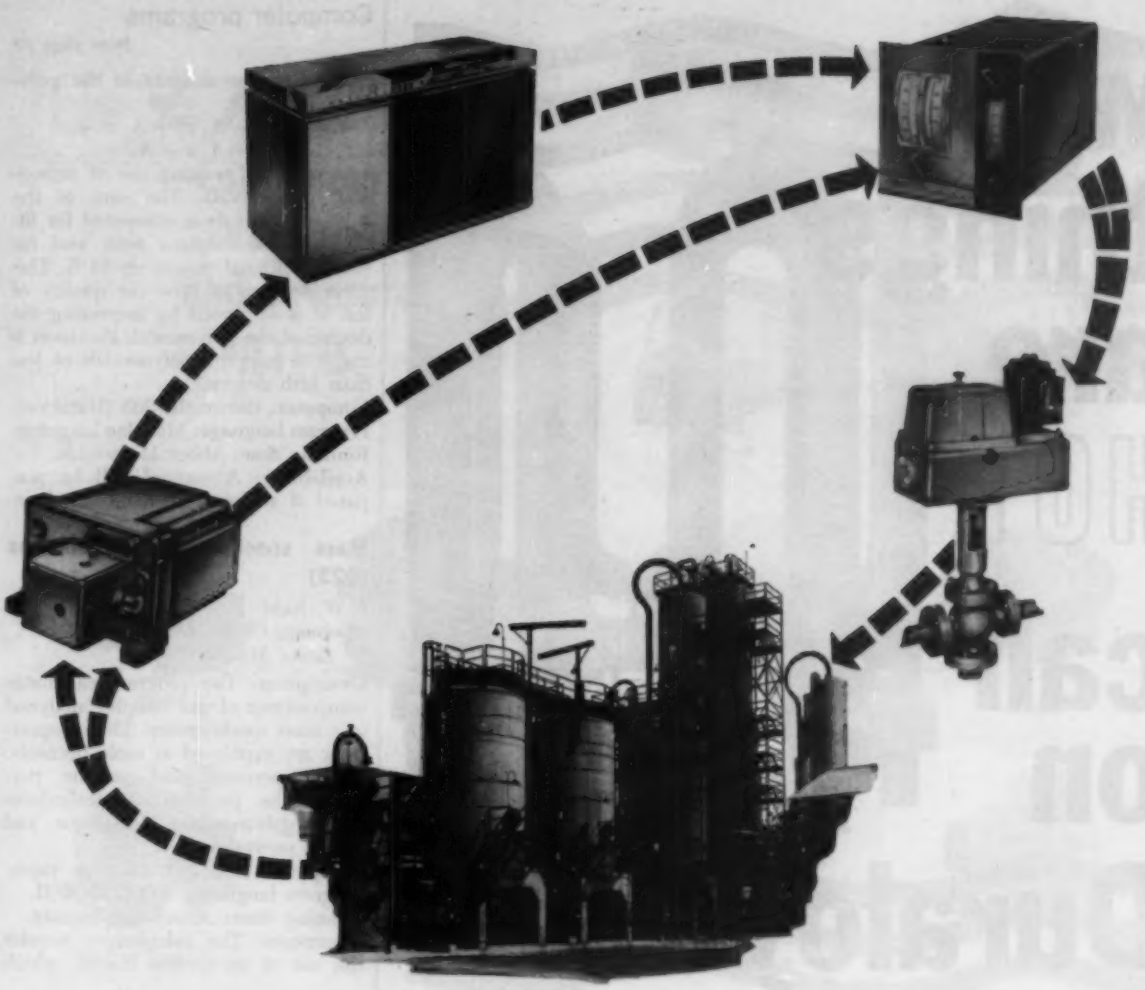
Availability: The manual on this sub-program was made available for publication on August 1, 1959.

Curve Fitting (022)

R. A. Eimer
Socony Mobil Oil Company
Paulsboro, New Jersey

Description: This routine fits a fifth-degree polynomial to ordinate values given at 11 equally spaced abscissa

continued on page 80



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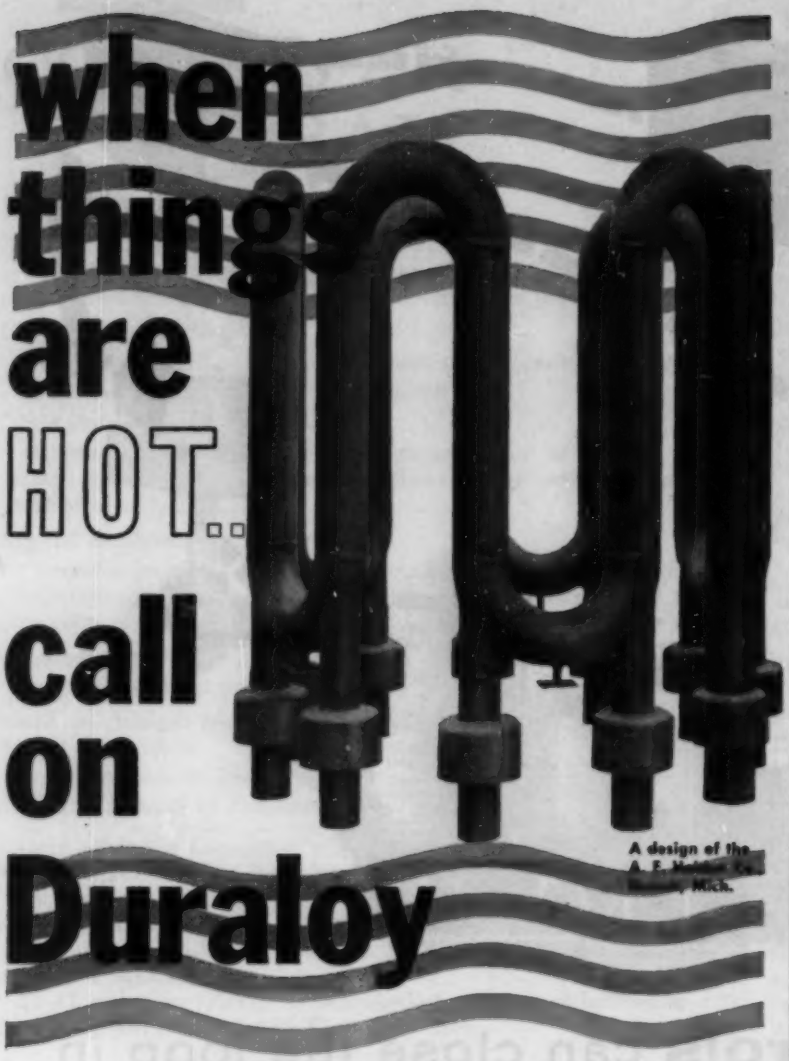

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For more information, turn to Data Service card, circle No. 22

Computer programs

from page 78

values. The coefficients in the polynomial

$$Y = A_5 x^5 + A_4 x^4 + A_3 x^3 + A_2 x^2 + A_1 x + A.$$

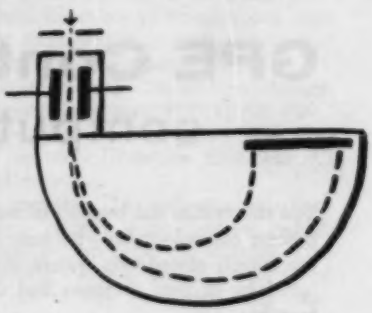
are computed making use of orthogonal polynomials. The sum of the squared residuals is computed for fitting with a constant term and for each additional power up to 5. This gives an idea of how the quality of the fit is improved by increasing the degree of the polynomial. Provision is made to compute polynomials of less than fifth degree.

Computer: Burroughs 205 (Datatron).
Program language: Machine language.
Running time: About 15 seconds.
Availability: A manual will be prepared if sufficient demand develops.

Mass spectrometer calculations (023)

J. W. Judd
Monsanto Chemical Company
St. Louis, Missouri

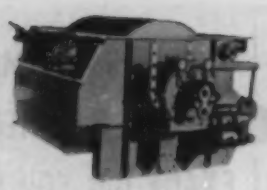
Description: The program calculates compositions of gas samples analyzed in a mass spectrometer. The compositions are expressed as mole percents, weight percents and volume percents. The program also calculates actual galvanometer deflections and partial pressures.
Computer: IBM 704, 8K core, tapes.
Program language: FORTRAN II.
Running time: About one minute.
Comments: The calculations require the use of an inverse matrix, which



can be entered initially from either punched cards or magnetic tape. At this time a permanent tape containing the inverse and its associated molecular weights and sensitivities is prepared by the program. Data requiring different inverses may be processed in one run, but all data sets requiring the same inverse must be together in the run. The number of different inverses used in one run is limited by the number of available tape units.
Availability: Manuals not available at this time.

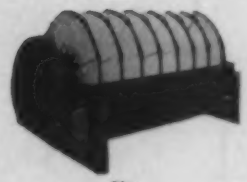
EIMCO

Continuous Vacuum and Pressure FILTERS

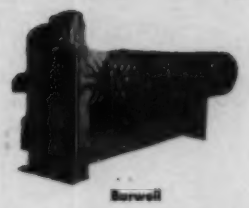

Precoat

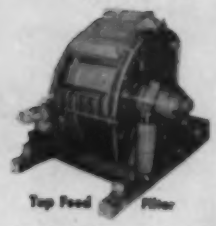
Pressure

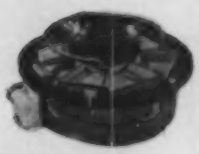
Drum

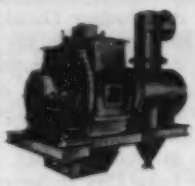

Disc

Agidisc

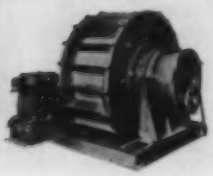

Burwell

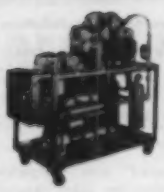

Top Feed Filter


Tilting Pan


Top Feed Dryer

Pilot Plant


Top Feed Dewaterer


Lab. Filter

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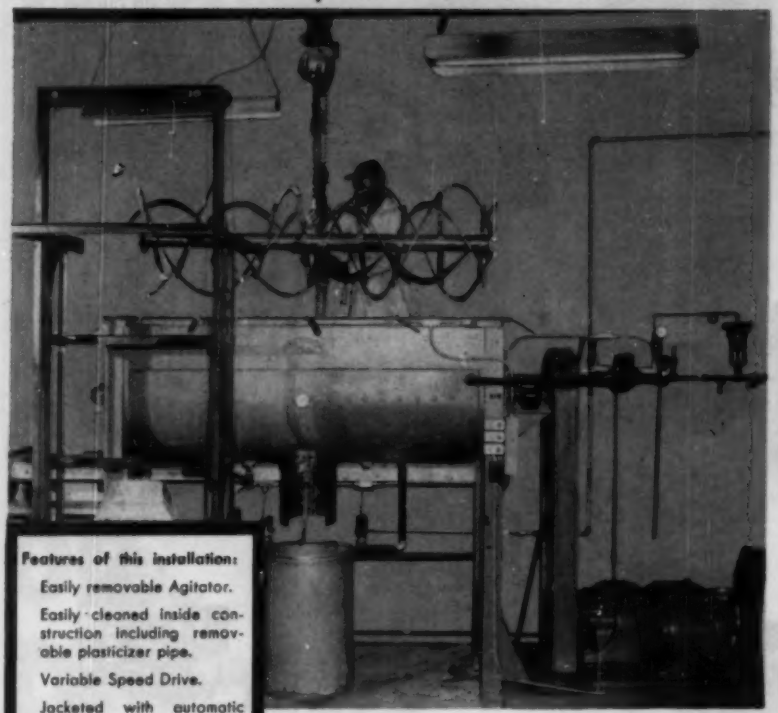

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Thermocouple for Temperature Control.

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institutional news

Active Nuclear Division builds impressive record

A.I.Ch.E.'s Nuclear Engineering Division has attained an important position in the fostering of chemical engineering activity in the constantly expanding nuclear energy field.

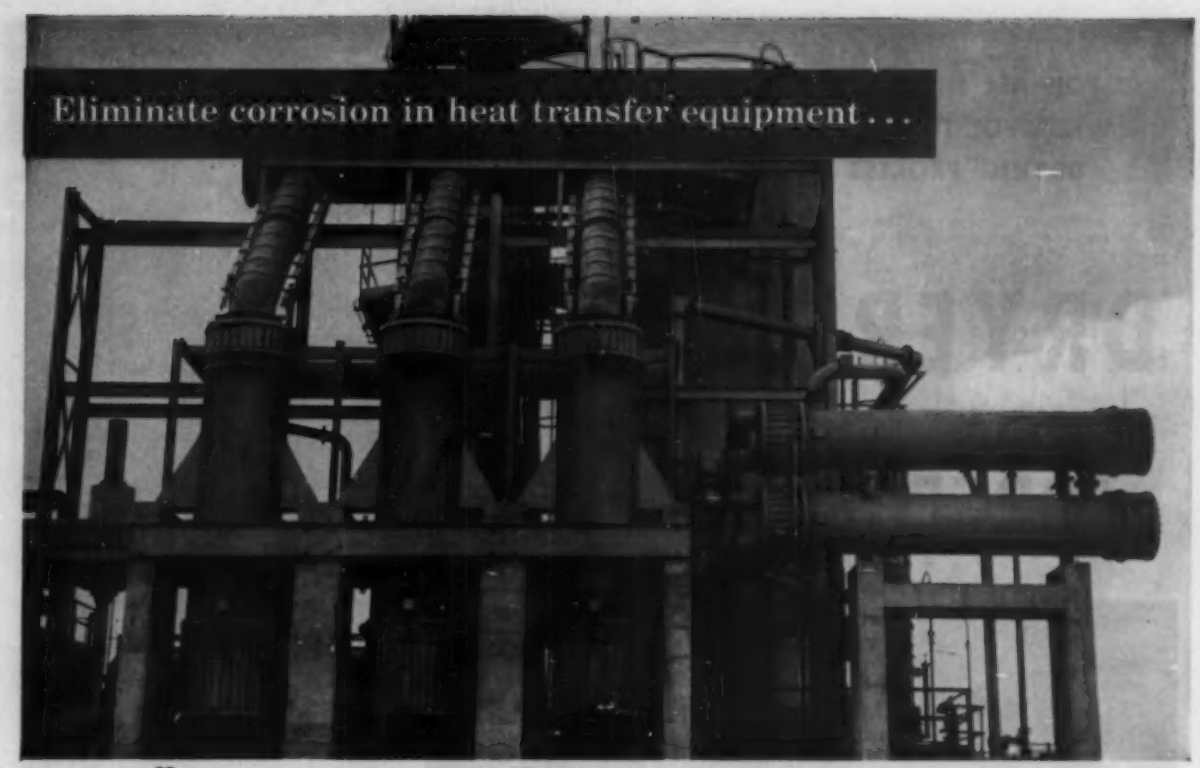
Impressive indeed is the 1958 performance record of the relatively new Nuclear Engineering Division of A.I.Ch.E. At the 1958 Nuclear Congress in Chicago alone, 28 papers were supplied by the Division: eight in chemical processing; five in thermal and mechanical design; four in fuel, control, moderator, and coolant materials; and three in reactor systems analysis. At the Joint A.I.Ch.E.-C.I.C. meeting in Montreal, April, 1958, a symposium on *Chemical Engineering Problems in Heavy Water Reactors* was sponsored and chaired by D. Stewart and W. M. Campbell of the Nuclear Division.

Chemical Engineering in the Nuclear Field, a 4-paper symposium under the chairmanship of R. P. Genereaux, was one of the high points of the Golden Jubilee meeting in Philadelphia in June of last year; while in Salt Lake City in September a 5-paper symposium on *Chemical Engineering in Nuclear Applications* was chaired by N. A. Spector, and a paper by D. H. Imhoff on *Fusion as a Future Energy Source* was presented.

The culmination of the Division's efforts in the initiation and preparation of papers came at the Annual Meeting in Cincinnati in December where two complete nuclear symposia were presented. *Reprocessing of Fluid Nuclear Reactor Fuels,* under the chairmanship of O. E. Dwyer, consisted of 6 papers, while J. L. Schwennesen's symposium on *Nuclear Fuel Processing—A Challenge for the Future* took the form of an 8-man panel discussion. In addition at Cincinnati, the Division arranged for a round-up report by W. K. Davis on *The Geneva Conference —1958.*

The Division's program has continued under full steam into 1959. Five technical papers made up a symposium presented at Atlantic City in March on *Process Data and Design Methods for Nuclear Fuel Recovery,* under the chairmanship of C. E.

continued on page 84



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Engineered for maximum corrosion resistance and minimum maintenance, these shell and tube heat exchangers are so constructed that all surfaces in contact with corrosive fluids are of "Karbate" impervious graphite. This unique material offers *complete corrosion resistance, high thermal conductivity and immunity to thermal shock.*

Always consider "Karbate" impervious graphite heat exchange equipment where corrosion is a problem. You'll be pleasantly surprised at the low first cost in comparison with heat exchangers having far less effective resistance to corrosion.

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Components of all sizes of "Karbate" heat exchangers are manufactured in quantity and carried in stock. You save money . . . you save time . . . when you specify "Karbate" impervious graphite shell and tube heat exchange units.

Series	Nom. Size Shell	No. of ¾" I.D. x 1¼" O.D.	HEAT TRANSFER SURFACE OUTSIDE TUBES, SQ. FT.				
			6' Long Tubes	9' Long Tubes	12' Long Tubes	14' Long Tubes	16' Long Tubes
90	6"	9	17.7	26.5	35.4	—	—
190	8"	19	37.3	55.9	74.5	87.0	99.5
310	10"	31	45.6*	91.2	121.6	141.9	162.2
420	14"	42	81.7	123.3	164.8	192	220
640	16"	64	124.3	187.7	251	293	335
850	18"	85	165.2	250	334	389	444
1090	20"	109	213	320	427	499	570
1350	22"	135	263	397	530	618	706
1630	24"	163	317	479	640	746	852
1950	26"	195	379	573	766	892	1017
2330	28"	233	453	684	914	1065	1217
2680	30"	268	521	786	1051	1225	1400
3490	34"	349	679	1024	1368	1595	1822
4390	38"	439	855	1289	1722	2009	2295
5960	42"	596	1162	1749	2336	2727	3118
6850	45"	685	1335	2010	2685	3135	3585

*This unit has 4½' long tubes.

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WHEREVER THERE'S A
DRYING PROCESS

DRYERS
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SARGENT

Does your product need short or long exposure drying? Is production measured in ounces or tons? Should it be batch or continuous process drying?
Whatever your needs, there's a SARGENT to do the job. SARGENT Dryers are working in widely varied industries — chemicals, rubber, food, tobacco, textiles — wherever there's a drying process. They are pre-dominant, industry-wide, in profitable operation. Each dryer has these "plus" advantages, standard in every SARGENT machine:

- Exclusive, pre-assembly method means record-breaking speed of installation at your plant.
- Heat source can be gas, oil, steam, electricity.
- Economical — use as little as 1.2 lbs. steam per pound of water removed.
- Drying uniformity; trouble-free operation.
- Rugged construction; takes the gaff of heavy volume production.
- Complete, hold-to-the-line, temperature and humidity controls.
- Dependable, high-level production at unprecedented economy.

Courtesy, American Industrial Clays, Inc., Sandersville, Ga.

SARGENT 2-Stage, Kaolin Dryer With Extruder

To meet required hourly production in design of this dryer, local conditions suggested the economy of using both gas and oil for the heat source. Combination type burners using both fuels on the same equipment, were therefore incorporated in its design for installation on top of the dryer housing with platforms for inspection and maintenance.

This SARGENT 22-section, 2-stage dryer delivers large tonnage hourly of filler or coating clays. Entering moisture is usually 35% wet basis; and leaves the dryer at 2% or less moisture content, as required. The unique SARGENT double hopper extruder feeds the dryer with a very even porous bed of clay on the dryer conveyor. Simple adjustments easily adapt this machine to various densities of clay.

Another example of SARGENT modern design and advanced engineering in building dryers to meet varying requirements.

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Graniteville, SINCE 1852 Massachusetts

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institutional news

from page 82

Stevenson. In April, at the Cleveland Nuclear Congress, approximately 25 A.I.Ch.E.-sponsored papers figured in five symposia. Nuclear Engineering Division representative on the Congress Program Committee was E. B. Gunyou.

Advisory function

A heavy additional load is being carried on a continuing basis by members of the Division who have assumed the task of reviewing nuclear papers for possible publication in *CEP* and the A.I.Ch.E. Journal. Special mention must be made in particular of the amount of work devoted to aiding in the preparation of the special February, 1959, Nuclear Issue of *CEP*.

The objectives of the Division are well summed up in the By-Laws:

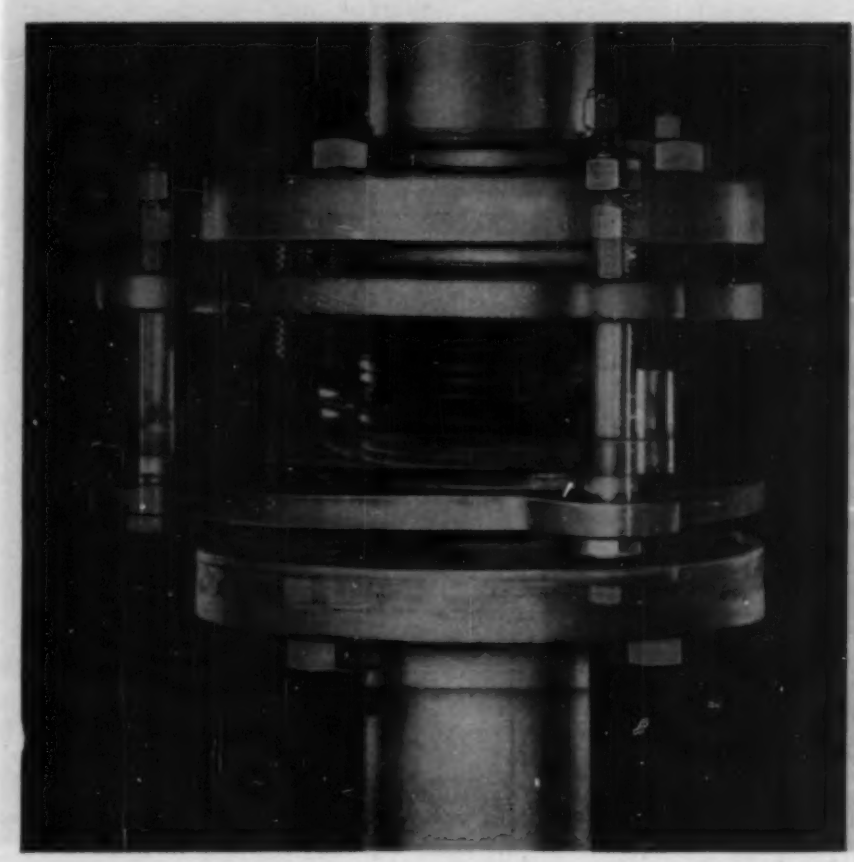
"To provide an opportunity for engineers and scientists interested in the field of nuclear engineering to meet and discuss problems of mutual interest;

"To promote publication and dissemination of information in this field; and

"To promote and coordinate educational activities in nuclear engineering between governmental agencies, industry, and academic institutions."

Maywood Chemical Works will be acquired by Stepan Chemical, Chicago. A producer of lithium, thorium, and rare earth chemicals, the Maywood, New Jersey, firm manufactures shampoo detergents, aromatic chemicals and flavoring compounds.

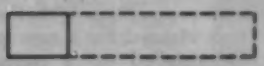
Completion of a 5350-ft. salt brine well brings the caustic-chlorine plant of Kaiser Aluminum and Chemicals at Gramercy, Louisiana to its rated operating capacity of over 100 tons a day. Caustic and chlorine are produced by electrolysis of the salt brine in the plant's main processng facilities, whch consist of 112 Hooker S-3B diaphragm cells rated at 30,000 amperes. The caustic chlorine facilities are part of the Gramercy Works.



MOLDED DESIGN

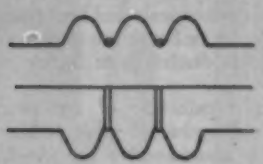
rounded interior convolutions, extra thickness at stress points

HIGH TENSILE STRENGTH



Teflon at its best, Fluoroflex-T provides at least 300% elongation

METAL REINFORCING RINGS



permit greater travel from shorter units, prevent distortion from surges

2 MILLION CYCLES AND STILL FLEXING!

...proving that this Teflon expansion joint—molded of Fluoroflex-T —outlasts most other materials and constructions

Chemical manufacturer: Tried Fluoroflex®-T joint, found it *still* flexing after *2 million cycles;* previously had averaged 100,000 cycles from machined Teflon® flex joint in pumping application.

Major industrial product company: Displaced one end of a special Fluoroflex-T bellows ¾-inch from its axis, rotated it around axis at 1,000 rpm. After *20 million cycles,* with still no sign of deterioration, test discontinued.

Petrochemical processor: Installed Fluoroflex-T joints to replace joints machined from Teflon. The Fluoroflex-T joints are still in service after nearly a year.

Fluoroflex-T flex and expansion joints perform so much better for three reasons: (1) *The material:* a patented compound of Teflon that combines high density with low crystallinity for optimum strength and flexibility. (2) *The process:* a unique technique for molding uniform convolutions with restraining rings. This gives undamaged grain structure, rounded interior convolutions and increased strength. (3) *The experience:* Resistoflex has been working with fluorocarbon resins since their inception. For fabricating with Teflon, such experience is *vital.* That's why Fluoroflex-T is Teflon at its best.

So, for corrosion-proof flex and expansion joints that give unsurpassed working life, specify Fluoroflex-T. Write for Bulletin B-1A. Dept. 293, RESISTOFLEX CORPORATION, Roseland, N. J. Other Plants: Burbank, Calif.; Dallas, Tex.

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Complete systems for corrosive service

RESISTOFLEX

For more information, turn to Data Service card, circle No. 26

Soda ash recovery process in operation

Commercial-scale installation at Consolidated Water Power & Paper in Wisconsin is said to promise economic recovery of pulping chemicals, stream pollution control.

Economic competition with the kraft process is claimed for a new process recently installed on a commercial scale at the Wisconsin Rapids Division of Consolidated Water Power & Paper. The Western Precipitation-developed process used is an adaptation of the Bradley process, is based on a sulfide recycle technique. It recovers pulping chemicals and heat from spent sulfite liquor for re-use in pulping, and prevents discharge of liquor into the river.

Basic principle of the process is the conversion of spent sulfite liquor into a non-corrosive solution that resembles the air-oxidized black liquor in kraft recovery; this similarity allows the use of standard kraft recovery equipment. (Earlier attempts at sulfite recovery required specially designed equipment to withstand the highly corrosive action of untreated spent sulfite liquor).

One major feature claimed for the new process is its ability to treat spent liquor from neutral sulfite semi chemical, sodium acid sulfite, or even kraft pulp, and to allow intermixing of liquors, if desired.

How it works

Spent liquor from the pulping process is treated with sodium sulfide and sodium carbonate (recovered from a previous batch of liquor). This treatment produces a liquor which is similar in characteristics to the air-oxidized "black liquor" of the kraft recovery process.

The treated liquor is evaporated to a 65% solids concentration and burned in a recovery furnace. This furnace acts as a chemical process unit, also as a high-pressure steam generator. Smelt formed by the combustion contains sodium sulfide and sodium carbonate in equimolar ratio, even though the proportion in the incoming liquor may vary widely. This 50% sulfidity in the smelt is fixed by the release of excess sulfur into the flue gases as sulfur dioxide.

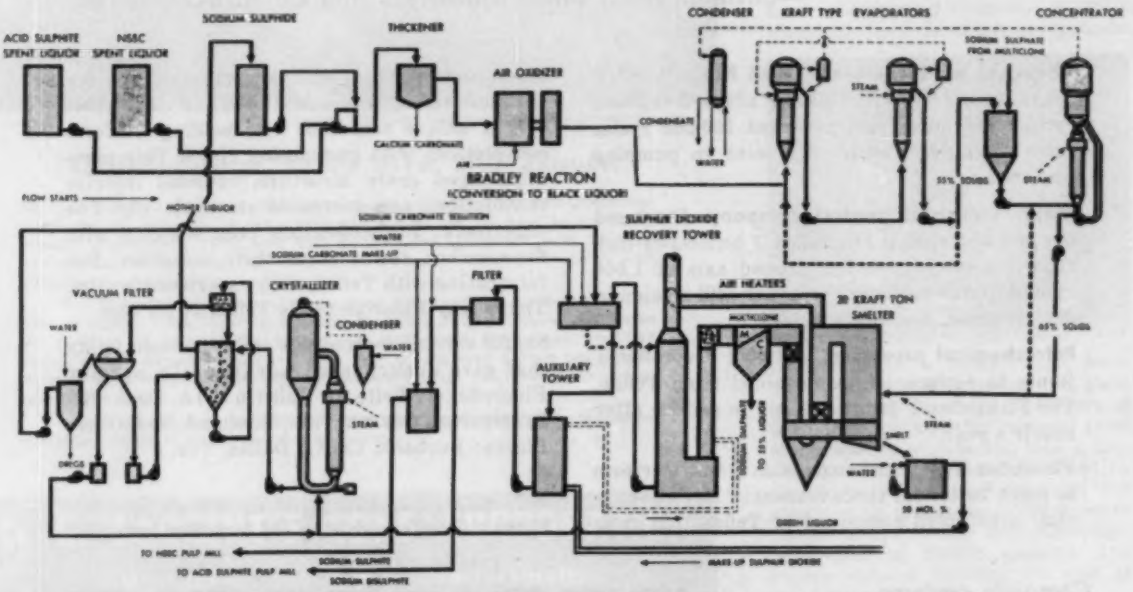
The smelt is dissolved with water to create a green liquor which is evaporated to recover pure sodium carbonate crystals. Remaining mother liquor from the crystallizer is sent back to treat the spent liquor at the beginning of the cycle. The sodium crystals are filtered, washed, and dissolved.

The furnace gases, which have a high level of sulfur dioxide, are put through a scrubbing tower where they are reacted with the purified sodium carbonate stream to create a weak sodium sulfite-bisulfite liquor. This sulfite liquor is then run through a raw acid tower where it is reacted with make-up sulfur dioxide from a standard sulfur burner. As full strength cooking liquor, it is then sent to the accumulator of the chip digester.

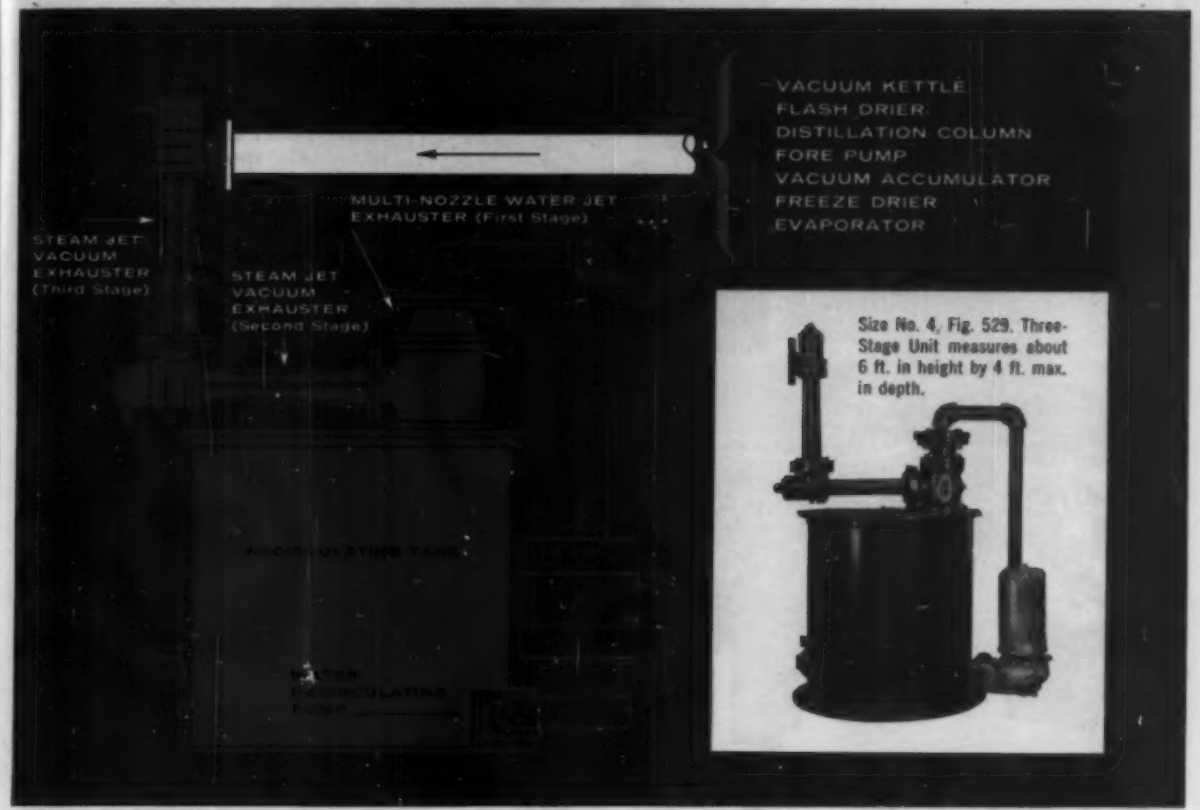
Economics

At Consolidated's 100 ton/day pulp mill, one digester has been modified to employ soda base sulfite pulping.

continued on page 120



Experimental recovery plant flow chart at Consolidated Water Power & Paper Co., 1957.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FLASH DRIER
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FREEZE DRIER
EVAPORATOR
MULTI-NOZZLE WATER JET EXHAUSTER (First Stage)
STEAM JET VACUUM EXHAUSTER (Third Stage)
STEAM JET VACUUM EXHAUSTER (Second Stage)
Size No. 4, Fig. 529. Three-Stage Unit measures about 6 ft. in height by 4 ft. max. in depth.

PRODUCE HIGH VACUUM QUICKLY & ECONOMICALLY

with this "Packaged" Hydro-Steam Unit

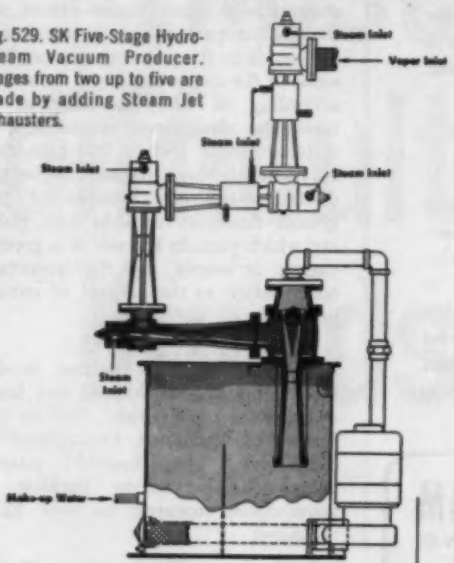

Fig. 529. SK Five-Stage Hydro-Steam Vacuum Producer. Stages from two up to five are made by adding Steam Jet Exhausters.

The unit shown is a "packaged" vacuum producer designed to operate at ground level. Using plant steam and make-up water, it will produce the low suction pressures required for many operations in chemical, food, and petroleum processing plants.

These units are made in a range of sizes in single-stage, two, three, four, and five-stage types. Depending upon size and type, units in this line will provide suction pressures ranging from atmosphere to 1.5 in. Hg abs (single-stage) up to 0.25 mm Hg abs to 25 microns Hg abs (five-stage).

SK "Packaged" Vacuum Producers offer specific, worthwhile advantages. They are simple in construction, are self-contained, compact, require little head room or floor space, are easily installed. Unlike mechanical vacuum producers, contamination presents no problems. They are operated easily, produce vacuum quickly, are economic, can be used intermittently or continuously as desired.

New Bulletin 5H-HS gives complete details on application, construction, operation including suction pressures provided and data on steam consumption and make-up water required. Send for a copy.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-T.
VALVES: Ask for Condensed Bulletin V-1.
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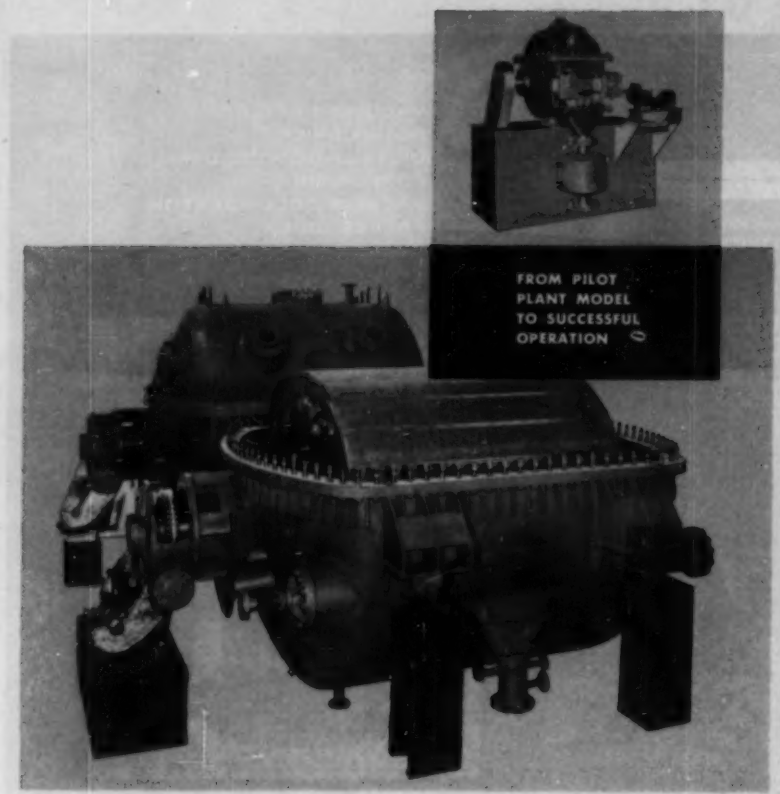

G-B Rotary Drum Pressure Filters for HIGH PRESSURE

This new filter was originally developed for the lubricating oil industry where high pressure is necessary to keep the solvents used from flashing. The two units shown above were recently installed in a foreign country for a propane dewaxing plant.

This filter has now been adapted for other uses such as high energy boron fuels, refractory materials and other high pressure, high temperature applications. It is available from 6 sq. ft. to 400 sq. feet and in pressures to 150 psig. Stainless steel, monel or nickel construction may be used in addition to mild steel. A 6 sq. ft. pilot plant model in stainless steel is available for rent as shown in the inset above.

GB

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FILTERS • EVAPORATORS
PROCESS EQUIPMENT
CONTRACT MANUFACTURING
including HEAVY CASTINGS

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Soda ash recovery

from page 86

If the new system performs well, the company expects to expand the recovery plant's capacity to process all recoverable spent sulfite and semi-chemical liquor from the entire mill. Successful operation of the new installation, says the company, will result in a substantial increase in use of northern mixed hardwoods.

Cost-wise, when compared to calcium base acid sulfite, soda base pulping plus the Western Precipitation recovery system is said to be advantageous only in the larger installations, since the inevitable washing losses of sodium base spent liquor cancel out the greater part of the chemical savings made in the recovery system. The value of the steam produced, however, according to W-P, is sufficient to make the changeover economical in installations of 150 to 200 tons/day. In addition, there are said to be the difficult-to-evaluate benefits of the greater flexibility of soda base pulping which permits the use of a greater variety of woods, and the important contribution to the control of stream pollution.

New recovery plant for conversion of spent sulfite liquor to soda and sulfur. Wisconsin Rapids Division of Consolidated Water Power & Paper.

A $90,000 research contract in the solid propellant fuel field has been awarded Metal Hydrides, Inc. by the Bureau of Ordnance, Department of the Navy. The classified project brings MHI's current backlog of government research to over $211 thousand.

Polyester and alkyd resins will be produced at a plant just put on-stream at Reichhold Chemicals, Houston, Texas. The million dollar facilities have also been designed to expand into production of other synthetic resin types.

the meter with NO flow restrictions

now handling all these difficult liquids

Foxboro's first Magnetic Flow Meter went "on stream" in 1954. Today, this new-type meter has gained industry-wide application for precise, continuous measurement of difficult process liquids.

The Magnetic Flow Meter is installed as simply as a length of pipe. It connects by standard electric cable to remote Foxboro Dynalog* Electronic Recorder. No seals, purges, meter runs, or straightening vanes are required. Over-all accuracy of the system is ±1%. And the meter even measures reversing flows.

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- rubber copolymer
- liquid latex
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- beer
- grape juice
- apple juice
- pineapple juice
- tomato juice
- milk
- starch slurry
- sugar syrup
- coffee slurry
- molasses

METALS AND MINING

- pickling acid
- sand slurry
- ferrous chloride
- limestone shale slurry
- bauxite slurry
- gilsonite slurry
- aluminate liquor
- uranium ore slurry
- thickener mud
- cement slurry
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METER SIZES RANGE FROM 1/10 INCH TO OVER 6 FEET PIPE DIAMETER

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Steels—carbon, alloy, stainless, stainless-clad

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industrial news

Tenth annual industry "School"

The technical knowledge of the practicing chemical engineer will necessarily increase, especially along the lines of process control, with the further development of automation, R. W. Rotzler told a group of chemical engineering instructors at an "Industry Teaches the Teacher" School in May. The tenth annual all-day school, held at Monsanto's Texas City, Texas, plant, gave the eighteen teachers representing six southwestern colleges a first hand look at instrumentation in the petrochemical industry.

Management's interest in instrumentation is profit, Rotzler stated. He mentioned that Monsanto is working on a design which will provide complete automation on one of their processing units. The combination of a modern high speed computer with more conventional instrumentation will automatically adjust controls for optimum operation of the unit. This optimizing action is a step beyond control of existing plants, he said. Rotzler's talk was part of an overall program which included a tour through the plant's manufacturing units.

The school was organized ten years ago by the chemical engineering projects committee with the aim of bringing the academic world into closer contact with modern industrial practices.

The Halowax plant of Union Carbide at Wyandotte, Michigan, just purchased by Koppers Co., will be operated by the company's Tar Products Division. The plant produces chlorinated naphthalene, chlorinated paraffin, and other chlorinated chemicals and resins.

New international organization formed by Nalco Chemical, Nalco International, C. A. will handle commerical transactions in Venezuela and other South American countries. Nalco de Mexico, S. A. de C. V. will distribute company products in Mexico.

Changes on the international scene also made by Pfaudler Permutit, which has created an international division. The unit will handle the administration and coordination of company plants abroad, as well as export sales from domestic plans. Pfaudler has manufacturing subsidiaries in Germany, Great Britain, Japan, Mexico, and Australia.

Complete Pump, Turbine and Controls

COFFIN IND TURBO PUMPS

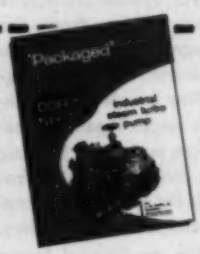
PACKAGED — integral design of the IND Pump results in a compact, highly efficient unit which mounts impeller and turbine wheel on a short, rigid shaft. The unit is equipped with complete controls for constant or differential pressure regulation.

APPLICATIONS — compact and highly efficient, the Coffin type IND Steam Turbo Pump is designed for General Boiler Feed or any other pumping service where medium volume and high pressure is required.

SPECIFICATIONS-

Capacities	to 180 GPM —	Height 32"
Discharge Pressures	to 350 PSIG —	Width 25"
Liquid Temperatures	to 300°F —	Length 32"

For special installations these ratings may be exceeded.



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Gentlemen: Please send me illustrated booklet further describing the Type "IND" Pump.

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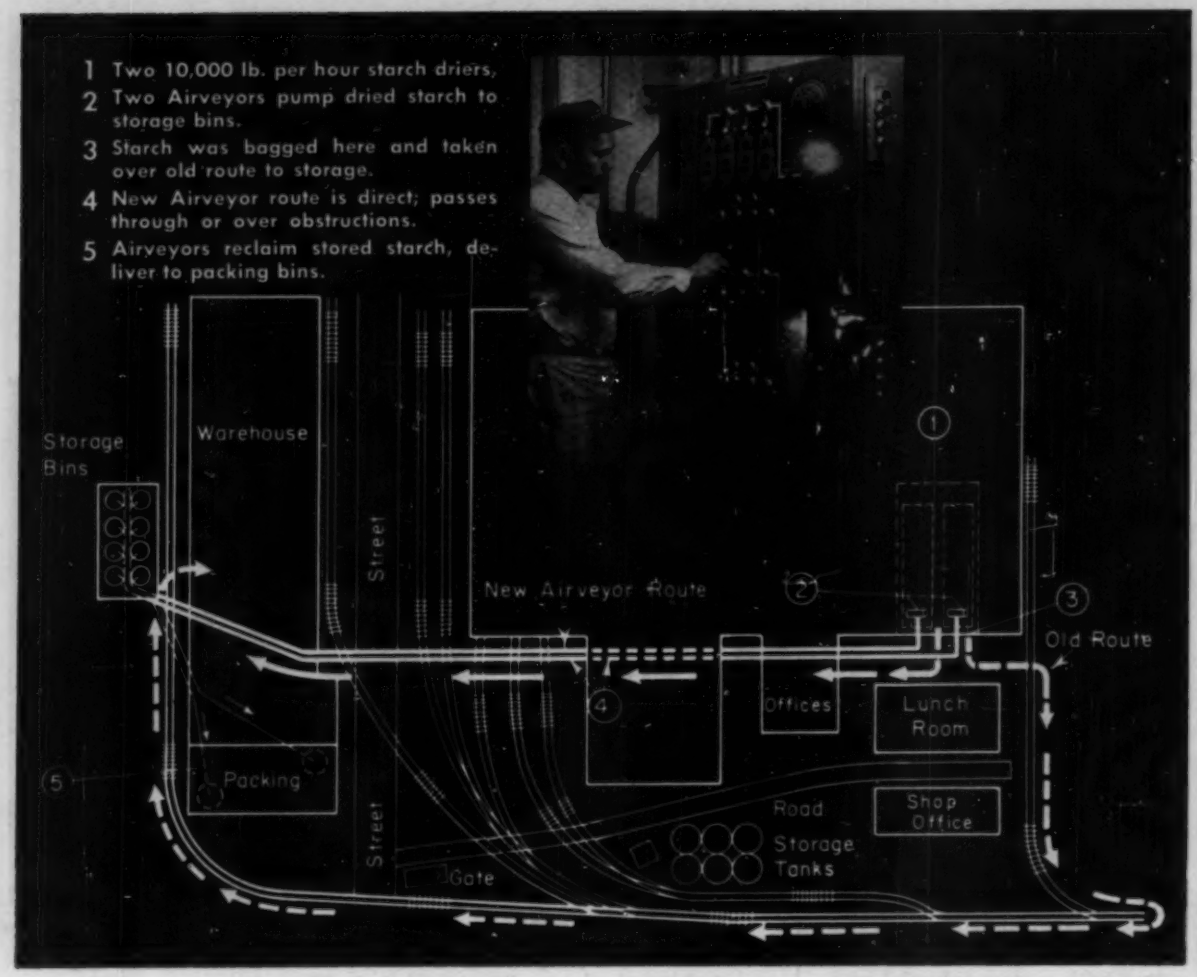
1 Two 10,000 lb. per hour starch driers,
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Street
New Airveyor Route
Old Route
Offices
Lunch Room
Packing
Shop Office
Road
Storage Tanks
Gate

PLANT MODERNIZATION THROUGH PNEUMATIC CONVEYING

FULLER pneumatic conveying system increases production without plant expansion

To increase production, the Union Starch and Refining Company's Granite City, Ill., plant first needed to expand their materials handling system. But a complete revamping of bagging and warehouse operations was impossible because there was no space available for necessary new buildings.

An Airveyor® System, engineered and built by Fuller, was the answer. Airveyor's extreme flexibility allowed it to be set up through walls, along sides of buildings, over streets, on roofs and up inclines. At Union Starch, the total distance covered is 800 feet, with a number of 45 degree and 90 degree bends in the line.

The Fuller Airveyor system transports the starch in two phases, from the driers to the storage bins and from the bins to receiving hoppers over the bagging machines. Flow is controlled automatically through control panels located in the drier room and at the bagging machines. Other controls are also provided at the panels for automatic operation of components such as feeders, blowers, conveyors and filter-receivers.

Besides being easily installed and automatically controlled, the Fuller system reduces both the amount and the expense of handling. Additional savings are made possible by Airveyor's self-cleaning facility, which greatly reduces maintenance costs.

Why not work with Fuller to design an automated pneumatic materials handling system that will help you cut costs and increase production? Write today for complete details. A-280 1383

For details on the Fuller Product line, see Chemical Engineering Catalog.

FULLER COMPANY
174 Bridge St., Catasauqua, Pa.
SUBSIDIARY OF GENERAL AMERICAN TRANSPORTATION CORPORATION
Birmingham • Chicago • Kansas City • Los Angeles • New York • San Francisco • Seattle

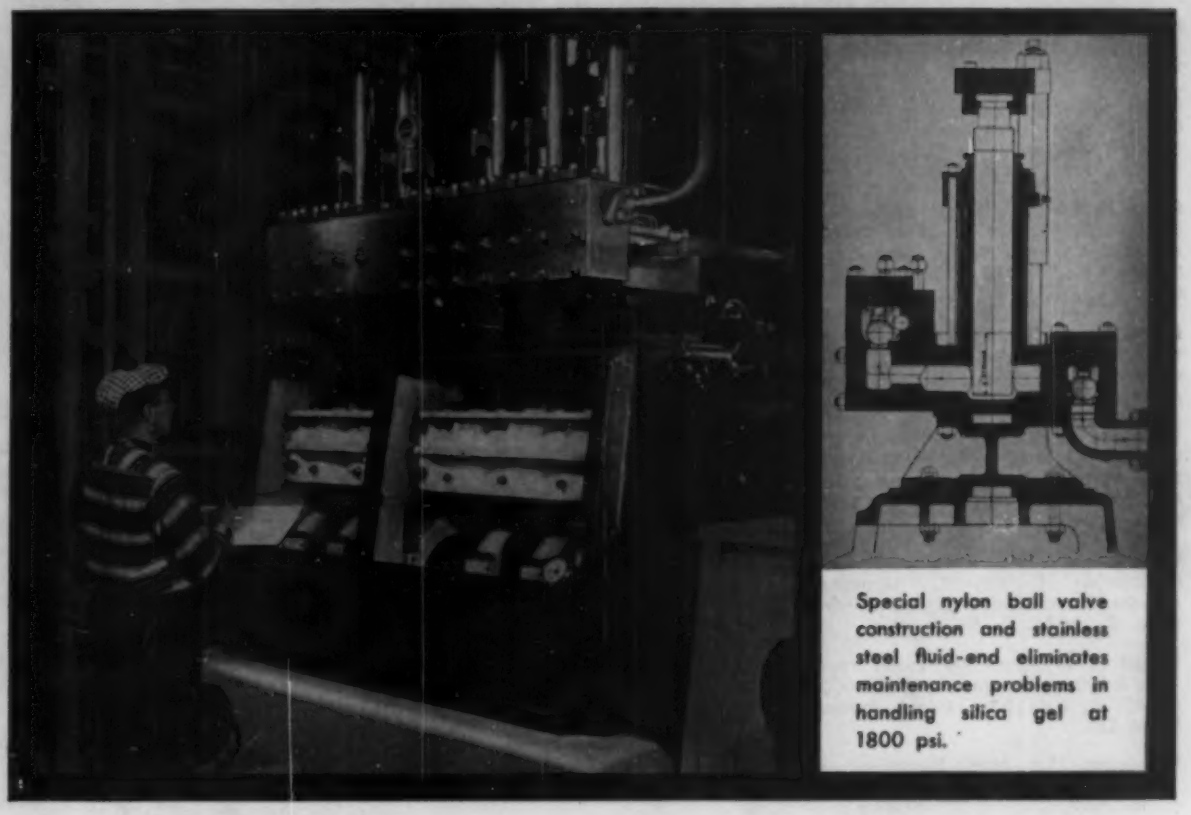
Fuller
pioneers in harnessing AIR

For more information, turn to Data Service card, circle No. 14

The following 4 Pages that appear to be missing are reader service cards and have been removed.

AT DAVISON CHEMICAL LTD.

Aldrich pumps tame highly abrasive, corrosive slurry in high pressure spray drying operation



Special nylon ball valve construction and stainless steel fluid-end eliminates maintenance problems in handling silica gel at 1800 psi.

When Davison Chemical Ltd. built its new plant in Valleyfield, Quebec, for the production of petroleum catalysts, a major problem was to find a pump that (1) had the abrasion and corrosion resistance to stand up in a continuous high pressure process without downtime or excessive maintenance and (2) could maintain the steady pumping pressures necessary to control particle size, density and porosity of the spray dried product.

What was done: Davison Chemical engineers called on Aldrich for help and the result was the special valve design shown. After two years of continuous operation, the Aldrich pumps continue to deliver constant pressure without major overhaul. The General Manager of the plant reports: "We are quite pleased with the performance of these pumps."

How Aldrich can help you: Solving special pumping problems for the chemical industry is the most important work we do. We would welcome the opportunity to discuss your specific problems . . . no matter what the liquid or slurry, or how high the pressures. Standard Aldrich Pumps range from 25 to 2500 hp. Pressures to 30,000 psi. See our insert in Chemical Engineering Catalog for condensed data. Aldrich Pump Company, 20 Gordon Street, Allentown, Pennsylvania.

the toughest pumping problems go to ALDRICH

For more information, turn to Data Service card, circle No. 113

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Equipment *from page 96*

Nozzles, spray (p. 122). Complete spray nozzle catalog from Binks Mfg. **Circle 25.**

Piping, non-corrosive (p. 108). Complete data from Fibercast, including Bulletin 20. **Circle 115.**

Piping, plastic, flexible (p. 12). Bulletin CE-57 from Ace Hard Rubber gives details of flexible poly pipe. Sizes ½ to 2 in., long coils. **Circle 71-1.**

Piping, rigid PVC (p. 12). Schedules 40, 80, & 120, ½ to 4 in. Threaded or socket-weld fittings. Valves ½ to 2 in. Bulletin CE-56 from Ace Hard Rubber. **Circle 71-2.**

Preheaters, air (p. 99). The Ljungstrom air preheater claimed to boost still capacity by up to 25%. Details from Air Preheater Corp. **Circle 119.**

Processor (p. 10). Info from Kontro on the "Ajust-O-Film," centrifugally-wiped, thin-film, short-time, continuous processor. Production units, pilot plant or rental facilities. **Circle 89.**

Pulverizers (p. 103). Bulletin 78 from Combustion Engineering, Raymond Div., on 18 and 35 in. Raymond vertical mills. **Circle 11.**

Pumps (p. 97). Standard models from 25 to 2,500 hp, for pressures to 30,000 lb./sq. in. Data from Aldrich Pump. **Circle 113.**

Pumps (p. 122). Nagle Pumps offers "Pump Selector" covering line of pumps built specially for abrasive applications. **Circle 99.**

Pumps, canned (p. 111). For system pressures to 5,000 lb./sq. in., temperatures to 1,000°F, capacities to 600 gal./min. Data Sheet from Chempump. **Circle 64.**

Pumps, centripetal (p. 133). New design allows handling of liquid, air, or liquid and air together. Details in Bulletin 725.6 from Goulds Pumps. **Circle 15-1.**

Pumps, controlled-volume (p. 13). Bulletin 440 from Lapp Insulator gives applications, flow charts, specifications, special leakage chart. **Circle 17.**

Pumps, for synthetic latex (p. 133). Details from Goulds Pumps. Bulletin 725.4. **Circle 15-2.**

Pumps, gear (p. 12). All wetted parts in acid and wear-resistant hard rubber. Bulletin CE-55 from Ace Hard Rubber. **Circle 71-3.**

Pumps, peristaltic action (p. 143). Complete info on sizes and capacities from Sigmamotor. **Circle 21.**

Pumps, process (p. 127). Bulletin EM-79 from Peerless Pump Div., Food Machinery and Chemical on "Mechanical Considerations in Pump Design." **Circle 35.**

Pumps, rotary gear (p. 136). Bulletin G-1 from Schutte and Koerting gives full details. **Circle 28.**

Pump, small, corrosion-resistant (p. 138). Zero to 2 gal./min. flow, Hastelloy C and Teflon construction. For labs and pilot plants. Data from Eco Engineering. **Circle 65.**

Pumps, small, corrosion-resistant (p. 140). Data from Randolph Co. on new design for handling of corrosives, abrasives, sterile solutions, gases. Two models—54 and 185 gal./hr. **Circle 37.**

Pumps, turbine (p. 91). Booklet from Coffin Turbo Pump describes new packaged design. **Circle 104.**

Refrigeration Unit (p. 113). The Chill-Vactor, made by Croll-Reynolds, is available in capacities from a few to 4,500 tons. Technical data. **Circle 73.**

DEVELOPMENT OF THE MONTH

NEW EXPANSION JOINT

(Circle 604 on Data Post Card)

Features of a newly-designed expansion joint include complete and uniform lubrication of the plastic packing material by a lubricant dispersion ring. The plastic packing can be replaced without taking the joint out of service. Only one lubrication fitting is needed.

An internal guide acts as inward and outward limit stop, to present the slip from being pulled out of the body. When the guide is in contact with the lubricant dispersion ring, the full pressure thrust is transferred back to the body. For complete details from Adsco Div., Yuba Consolidated Industries, Circle 604 on Data Post Card.

Refrigeration Unit (p. 145). Bulletin K-8 from Fisher Governor describes application of the Hilsch Vortex Tube to small-scale heating or cooling requirements. **Circle 105.**

Rotameters (p. 28). "Safeguard" rotameters, made by Schutte and Koerting, now available with polyvinyl chloride end fittings. Bulletin 18RG. **Circle 84.**

Screeners (p. 5). For single or multiple separations down to 325 mesh, laboratory or production-size models. Bulletin 503 from B. F. Gump describes the "Bar-Nun" sifter. **Circle 53.**

Separators, entrainment (p. 4). Improve performance of evaporators, scrubbers, absorbers, tail gas stacks. Bulletin 21 from Otto H. York describes the "Yorkmesh Demister." **Circle 31.**

Sight Glasses, Pyrex (p. 140). Squares, rectangles, odd shapes in 8 thicknesses, sizes up to 24 by 60 in. Bulletin from Swift Glass Div., Swift lubricator. **Circle 24.**

Tanks, wood polymer-lined (p. 126). Data from Wendnagel on "Polycel" tanks. **Circle 23.**

Tester, iron (p. 150). Contains standards covering 0-10 ppm range. Data from W. A. Taylor. **Circle 20-3.**

Tubing, plastic (p. 36). Complete technical data, other info on "Tygon" plastic tubing in Bulletin T-97 from U. S. Stoneware. **Circle 44.**

Vacuum Producers (p. 87). Bulletin 5H-HS from Schutte and Koerting describes packaged vacuum producers, gives details of application, construction, operation, steam consumption. **Circle 40.**

Valves, (p. 12). All-plastic, rubber-lined, or all-hard rubber. ⅛ in. pet cocks to 24 in. gate valves. Technical data from Ace Hard Rubber. **Circle 71-4.**

Valves, cast stainless (p. 21). Complete technical info from Cooper Alloy. **Circle 7.**

Valves, high-pressure (p. 34). New "Flo-Ball" design claimed to have more than twice the flow efficiency of needle valves for pressures to 3,000 lb./sq. in. Catalog from Hydromatics. **Circle 2.**

Valves, plastic-coated (p. 123). An economical answer to problem of alkalies, mild acids, sea water, other neutral salts. Data from DeZurik. **Circle 62.**

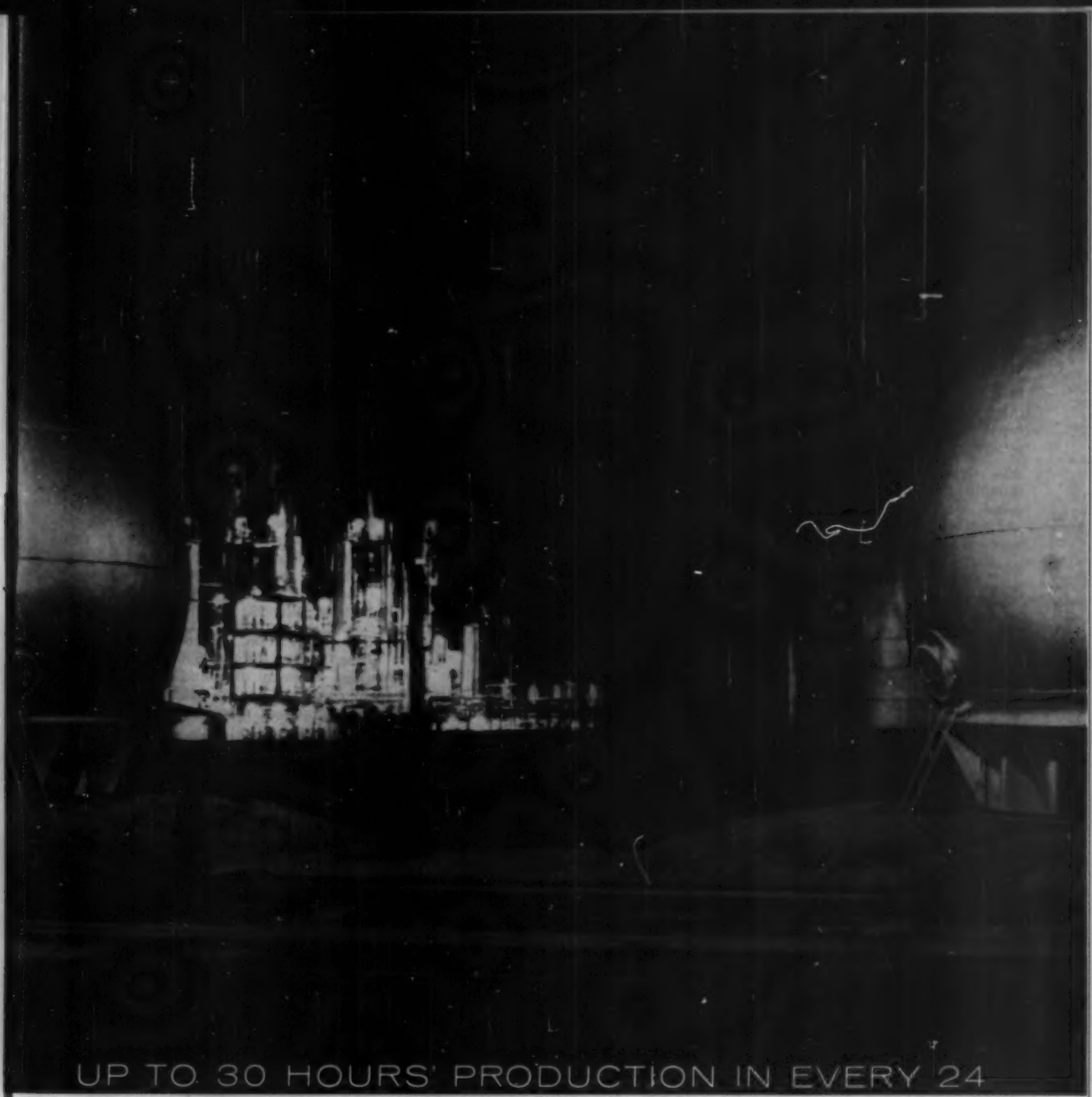
Valves, relief (p. 105). In any castable metal. Data from Vapor Recovery Systems. **Circle 94.**

Water Treating Equipment (p. 134). Complete plants for demineralization, dealkalizing, clarification, silica removal, water softening, iron and manganese removal. Catalog from Hungerford & Terry. **Circle 69.**

Water Treating Equipment. (p. 146). New 4-page Bulletin 615 from Elgin Softener describes variety of water treating methods. **Circle 1.**

Weigher, continuous (p. 14). Bulletin 958 from Stephens-Adamson describes continuous weighing unit said to eliminate all discharge terminal errors. **Circle 19.**

Wire Cloth, anti-corrosive (p. 30). Wire cloth or fabricated parts in all widths, all meshes, all malleable metals. Info from Newark Wire Cloth. **Circle 34.**



UP TO 30 HOURS' PRODUCTION IN EVERY 24

WHEN **AIR PREHEATERS®** BOOST STILL CAPACITY

You can boost the capacity of your stills by as much as 25% with a Ljungstrom Air Preheater, because an Air Preheater can recover as much as 1000°F from the still exhaust and put this recovered heat back into the combustion air. As a result your fuel burns more completely, at higher temperatures — and you get more product from every hour of still operation.

Equipment availability improves with an Air Preheater, too. There's less slag, fewer deposits when fuel burns in preheated air. Oil tubes stay clean, stills stay on-stream months longer, with less downtime for routine maintenance.

Air Preheater saves money other ways, too. If you're refining corrosive crudes or operating stills at very high temperatures, consider replacing all or a part of your convection surfaces with an Air Preheater. That way you minimize your need for expensive heat- and corrosion-resistant alloys, and get up to 25% savings on fuel bills.

One company's fuel savings with a Ljungstrom Air Preheater are factually described in a published magazine article by O. F. Campbell. Write today for your free copy to The Air Preheater Corporation, at the address below.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

For more information, turn to Data Service card, circle No. 119

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Absorbers, impervious graphite. Catalog AB-505 from Falls Industries gives details of falling film, packed tower, jacketed tower, and internally-cooled tower types.

302 Analyzer, particle size distribution. Bulletin 101 from Sharples describes the "Micromerograph", designed for rapid particle size determinations of powdered materials.

304 Cells, chlorine-caustic. Revised Bulletin 20-A from Hooker Chemical gives operating performance data, plant flow sheet, data on cell operation and renewal.

305 Chlorination Cell. New 12-page Brochure from Diamond Alkali gives details of new sensing element, designed for pulp chlorination applications.

306 Compressors. Complete technical details of new line of high-speed, multi-stage centrifugal compressors from York Corp.

307 Compressors. Bulletin APP-459 from Gast Mfg. gives application ideas for use of air motors, air compressors, vacuum pumps.

308 Compressors, heavy-duty. Specifications and dimensions of six basic models from 350 to 1, 250 hp and 2, 148 to 7, 392 cu. ft./min. Bulletin from Joy Mfg.

309 Compressors, multi-stage, high-pressure. Catalog 44 from Norwalk Co. gives details of all types, conversion tables, ordering info.

310 Compressors, turbo-charged. Bulletin 90 from Cooper-Bessemer gives specifications, construction details.

311 Computers, analog. New Catalog from George A. Philbrick Researches covers operational amplifiers, manifolds, linear and non-linear operators, regulated power supplies.

312 Computer, digital. New 6-page Bulletin from Bendix Computer describes the G-15 general purpose digital computer. Includes information on programming systems, punched cards, magnetic tape, paper tape, other auxiliary equipment.

314 Computer, process control. Brochure from Burroughs, Electro Data Div., describes applications of the Burroughs 205 digital computer in the petrochemical industry.

315 Controls. Catalog 306 from Amot Controls covers thermostats, controls, switches, valves, safety controls.

continued on page 102

MATERIALS

370 Acetophenone. Physical properties, specifications, solubility data, vapor pressure, specific gravity, in new Bulletin from Union Carbide Chemicals.

371 Aluminas. Properties, characteristics, uses of various aluminas in new 16-page Booklet from Kaiser Aluminum & Chemical.

372 Caustic Potash. New 60-page Technical Booklet from Solvay Process Div., Allied Chemical, presents properties of caustic potash, gives handling data.

373 Cellulose Acetate. Brochure from Eastman Chemical Products describes use of cellulose acetate for protective coating formulations.

374 Chemicals, industrial. Products List from Foote Mineral gives specifications of complete line of chemicals, metals, ferro-alloys, mineral products.

375 Coatings, protective. Three Case History Folders from Metalweld describe tank car lining systems, metallizing of process vessels, rubber-lined continuous pickling system.

376 Ethylene Carbonate. New 16-page Bulletin from Dow Chemical gives reaction and application info, toxicity data, annotated bibliography.

377 Fatty Acids. New Catalog from A. Gross & Co. gives specifications of stearic and oleic acids, tallow fatty acids and glycerides, vegetable fatty acids and glycerine.

378 Fatty Alcohols. New Data Sheet from M. Michel & Co. lists 19 fatty alcohols available in big tonnage quantities.

379 Gases, industrial. Bulletin from Air Reduction discusses properties, applications of oxygen, nitrogen, argon, helium, acetylene, hydrogen, carbon dioxide, rare gases. Conversion tables.

380 Heat Transfer Cement. Bulletin 300 from Thermon Mfg. describes properties, applications of inorganic heat transfer cement with highly efficient heat transfer characteristics.

381 Isobutyl Alcohol. Bulletin B-104 from Eastman Chemical Products discusses uses of isobutyl alcohol as solvent and chemical intermediate.

382 Iso-decanoic Acid. Technical information from Union Carbide Chemicals.

383 Magnesium Hydride. Properties, reactions, uses, handling precautions. New 16-page Bulletin from Dow Chemical.

continued on page 104

SERVICES

394 Consulting Services. Brochure from Raphael Katzen Associates describes facilities for economic studies, new plant design, staff training, assistance in management problems.

395 Conversion Factor Chart. Reference Table in form of wall chart offered by Precision Equipment Co.

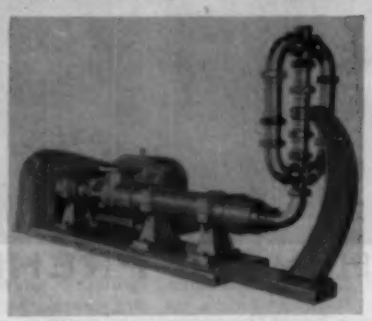
396 Fabrication, process equipment. Bulletin from Boardman Co. describes facilities for fabrication of all types of chemical processing equipment.

397 Fabrication, process equipment. Data from Industrial Filter & Pump on pressure filters, ion exchangers, demineralizers, centrifugal pumps, heat exchangers, waste treatment systems. Bulletin GEN-58.

398 Fabrication, process equipment. New 68-page Catalog 596 from Syntron gives technical data and specifications on complete line of chemical processing equipment made by the company.

399 Fabrication, process equipment. New Bulletin 59 from Bauer Bros. describes hammer mills, double and single disc attrition mills, single and double roll crushers, magnetic separators.

DEVELOPMENT OF THE MONTH



ULTRASONIC HOMOGENIZER

(Circle 603 on Data Post Card)

A new unit using 9,000 gph ultrasonic heads (mechanical transducers) is said to have extended the upper range of output for sonic homogenizers. Basic principle is the development and use of the kinetic energy in the liquids. The liquids to be emulsified impinge in the form of a flat, high-pressure jet stream on the edge of a blade which vibrates at its natural frequency about 22,000 cps. Cavitation takes place continuously in the stream rushing past the blade, causing violent pressure changes in the resonant bell. These pressure changes are put to work in the liquids with virtually no loss. For complete technical data from Sonic Engineering, Circle 603 on Data Post Card.

NEW G-54 GIRDLER CATALYST FOR IMPROVED SELECTIVE HYDROGENATION OF ACETYLENES

Here is another new, improved Girdler Catalyst... a development of our Research and Technical Service. G-54 is a promoted cobalt molybdate catalyst on an improved carrier for selective hydrogenation of acetylenes in raw olefin streams. Thoroughly tested and proven, G-54 offers these important benefits, compared to previously available catalysts, for this application:

- ***Higher activity.*** Permits greater space velocities... greater output and reduced operating costs with existing facilities. Reduces capital investment for new plants.
- ***Greater flexibility.*** Is selective and active over wider range of operating conditions such as feed gas composition, including variations in sulfur level.
- ***Improved selectivity.*** Less hydrogenation of olefins than with previously available catalysts.
- ***No steam addition required.*** Proven performance with increased cycle length, without addition of steam.
- ***Longer cycles.*** Minimizes polymer formation, extending periods between regenerations to 15 to 40 weeks.
- ***Prolonged life.*** Improved carrier and less frequent regenerations increase catalyst life.

For further information contact...

GIRDLER CATALYSTS

CHEMICAL PRODUCTS DIVISION • CHEMETRON CORPORATION

LOUISVILLE 1, KENTUCKY • Phone: SPring 8-4421

CHEMETRON

For more information, turn to Data Service card, circle No. 43

CEP'S DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Equipment *from page 100*

316 Crushers. Bulletin 54-C from Pulverizing Machinery Div., Metals Disintegrating, gives details of laboratory, standard, and heavy-duty models of the "Mikro" crusher.

317 Distillation Equipment, high-vacuum. Bulletin 3-1 from Rochester Div., Consolidated Electrodynamics, gives theory, equipment specifications.

318 Dry Processing Equipment. Bulletin from Sturtevant Mill describes air separators, pulverizers, blenders, mixers, crushing and milling machines, grinding mills, granulators.

319 Dust Collector, centrifugal. Bulletin from American Air Filter gives specifications and characteristics of collectors ranging from 9,000 to 72,000 cu. ft./min. capacity.

320 Eductors, fluid-mixing. Mixing eductors equipped with regulating spindles perform intimate mixing, blending, emulsification of two fluids. Bulletin 2M-S from Schutte and Koerting.

321 Ejectors, jet. Bulletin from Ingersoll-Rand describes Series M ejectors, designed to operate with steam or motive gas at 75 to 200 lb./sq. in gauge.

322 Equipment, corrosion-resistant. New 28-page Bulletin from Haveg Industries gives details of many types of chemical processing equipment in reinforced plastics. Tables of physical properties, chemial resistance.

323 Equipment, PVC. New Bulletin from J. E. Lonergan covers use of PVC in valve trim and diaphragm protectors.

324 Feeder, chemical, low-capacity. Pumping rate adjustable from 1.9 to 22.8 gal./min. Bulletin 1913. 20A-L from B-I-F Industries.

325 Filters, disc-type. Bulletin from Dorr-Oliver gives design data, operating characteristics of disc-type filters in chemical processing.

326 Flowmeters. Catalog from Eclipse Fuel Engineering gives technical details of complete line of flowmeters, flowswitches, manometers, for gases only, liquids only, combined liquids and gases.

327 Flowmeters. New 8-page Bulletin from Matheson gives complete technical details of new line of flowmeters for wide variety of flow ranges.

328 Flowmeters, electronic. Bulletin 604 from Burgess-Manning describes features, principles of operation, specifications, mounting dimensions.

329 Flowmeter, turbine-type. Capacities from 0.1 to 100,000 gal./min. Bulletin from Bowser gives technical details of the "Pottermeter."

330 Fluid Processing Equipment. Buyers Guide (Bulletin 980) from Pfaudler Permutit details equipment and services for handling and processing liquids and gases.

331 Generators, hydrogen. Bulletin H459 from Gas Atmospheres includes flow chart, tables of capacities, utilities, generator dimensions.

332 Heat Transfer Equipment. New condensed Bulletin 593 from Brown Fintube describes heat exchangers, fired indirect heaters, tank heaters, custom-built processing equipment.

333 Heat Treating Furnaces, atmosphere. New 8-page Booklet from Ferrotherm on "Heat Treatments in Atmosphere Furnaces" covers annealing, brazing, hardening, gives technical info on protective atmosphere.

334 Laboratory Glassware. New Catalog 60 from Ace Glass lists complete line of laboratory glassware and accessories.

335 Low Temperature Equipment. New 44-page Book from Hofman Laboratories covers developments in low-temperature chemistry, solid state physics, etc.

336 Mixer, continuous, pilot-plant. In-line unit said to eliminate intermediate storage tanks and mixing vessels. Data from Nettco on the "Flowmix."

337 Nozzles, spray. Data Sheet 8255 from Spraying Systems describes new line of hard rubber atomizing nozzles for corrosive applications.

338 Periscopes, industrial. Bulletin from Lenox Instrument gives specifications, sizes, describes applications including chemical processing.

339 Piping, flexible rubber. New type "Gen-Lok" flanged flexible rubber-pipe available in all standard diameters and any standard length. For pressures to 250 lb./sq. in. Bulletin 580 from General Rubber Corp.

340 Pumps, centrifugal. Stainless 316 construction throughout, capacity 50 gal./min., pressure to 20 lb./sq. in. portable. Details from Stainless Steel Pump Co.

341 Pumps, ceramic-lined. New model RXA, made by Kansas City Hay Press, is specially adapted to handle corrosive, abrasive materials. Technical data.

342 Pumps, high-pressure. Autoclave Engineers offers new 12-page Bulletin with complete technical data on hand, motor, and air-operated high-pressure pumps for pressures up to 60,000 lb./sq. in.

DEVELOPMENT OF THE MONTH

CONTINUOUS LABORATORY MIXER

(Circle 601 on Data Post Card)

A small model expressly designed for research, experimental, and small pilot plant work. Available from E. T. Oakes Corp. as an integral unit, with direct connected variable speed drive or as a separate unit for belt drive. For Bulletin with complete particulars, Circle 601 on Data Post Card.

343 Pumps, petroleum process. Info from Goulds Pumps on two new pumps for the petroleum and petrochemical industries.

344 Pumps, steam turbine. Folder from Coffin Turbo Pump describes packaged unit specially designed for medium volume and high pressure.

345 Pumps, turbine, short-coupled. Allis-Chalmers offers new line of centrifugal, short-coupled, turbine units. Forty sizes from 20 to 8,000 gal./min., heads to 400 ft. Technical data.

346 Pumps, turbine, vertical. Newly-redesigned "Ultra High Flow" turbine pump claimed to offer broader coverage, higher efficiencies. Technical Bulletin from Worthington.

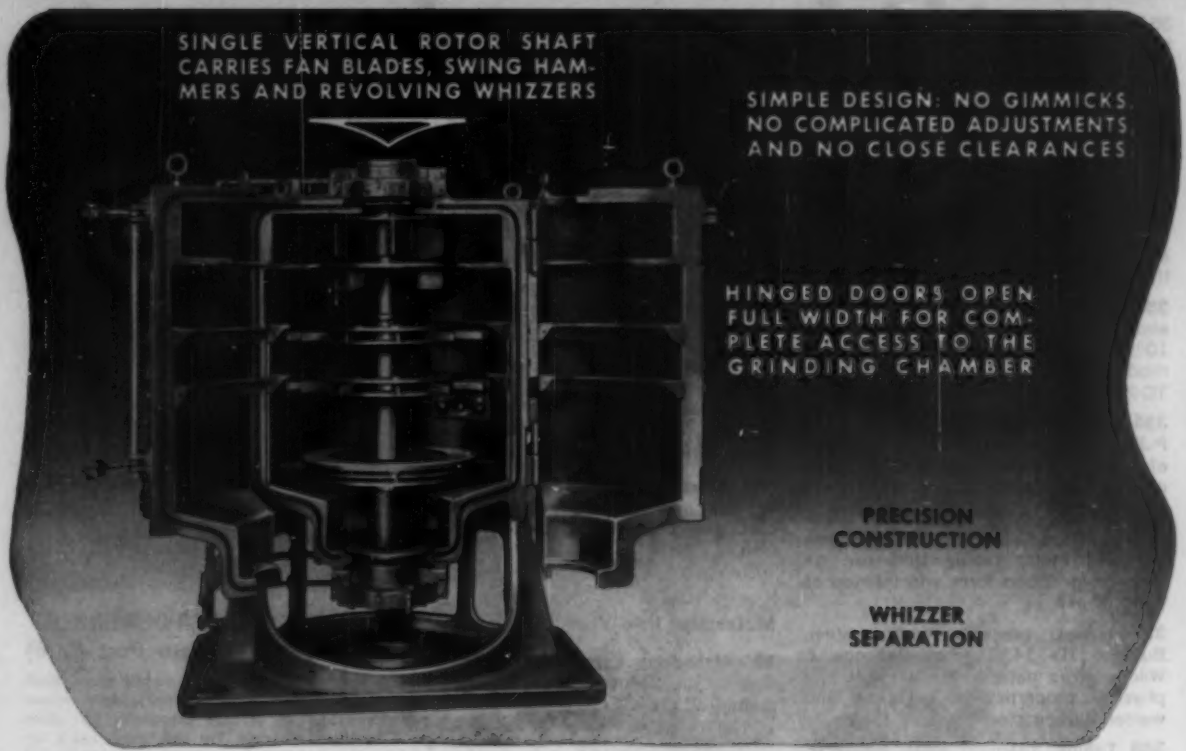
347 Readout System, multiple pressure. New 12-page Catalog 30B1000 from Fischer & Porter describes new system which measures and records hundreds of different pressures simultaneously with single high-accuracy transducer.

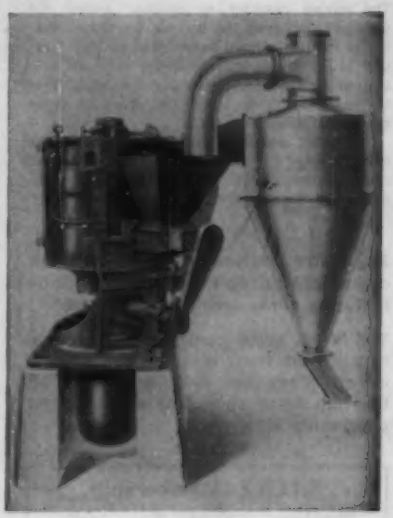
348 Recorder, bar-chart. Records down time on 22 machines simultaneously on single chart. Data from Gorrell & Gorell.

349 Recorder, vapor pressure, continuous. Bulletin from Hallikainen Instruments gives specifications, operating and installation data, flow diagram.

350 Separators, entrainment. Bulletin 25 from Otto H. York describes process application of "Yorkmesh Demisters." *continued on page 104*

For economical production of HIGH FINENESS MATERIALS


SINGLE VERTICAL ROTOR SHAFT CARRIES FAN BLADES, SWING HAMMERS AND REVOLVING WHIZZERS
SIMPLE DESIGN: NO GIMMICKS, NO COMPLICATED ADJUSTMENTS, AND NO CLOSE CLEARANCES
HINGED DOORS OPEN FULL WIDTH FOR COMPLETE ACCESS TO THE GRINDING CHAMBER
PRECISION CONSTRUCTION
WHIZZER SEPARATION



RAYMOND VERTICAL MILL

Quick accessibility is a main feature of design in this modern Raymond pulverizing unit. By loosening a couple of star nuts, the door can be swung open to expose the complete interior with all working parts in a few seconds. This permits easy inspection and cleaning, or making changes from one grade to another with a minimum of downtime for set-ups.

The Vertical Mill does an efficient job of pulverizing non-abrasive products to extremely high fineness ranging from minus 325 mesh into the sub-sieve sizes. On some softer materials, the finished products may be reduced to 95% to 98% finer than 5 to 10 microns in this mill. It is equally effective in grinding tough or fibrous materials where close fineness control is required.

Exterior view of 35" Raymond Vertical Mill shown at left. Write for Bulletin No. 78 which describes the 18" and 35" Vertical Mills.

COMBUSTION ENGINEERING, INC.

1126 WEST BLACKHAWK ST.
CHICAGO 22, ILLINOIS

Raymond Division

SALES OFFICES IN PRINCIPAL CITIES

Combustion Engineering-Superheater Ltd., Montreal, Canada

For more information, turn to Data Service card, circle No. 11

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Equipment *from page 102*

351 Size Reduction Machinery. Memo-Index from Gruendler Crusher & Pulverizer enables determination of proper machinery for efficient reduction of more than 200 different materials.

352 Speed Reducers. Bulletin 5908 from Western Gear gives selection data, specifications, ratings, dimensions.

353 Synthetic Rubber Components. Data from Pacific Moulded Products on equipment components in natural, synthetic, silicone rubber compounds.

354 Thermocouple Wire. Specifications and properties of platinum, platinum-10% rhodium, and platinum-13% rhodium thermocouple wire in Bulletin TC-2 from J. Bishop & Co.

355 Tube Protectors, plastic. Bulletin P-335 from Crane Packing gives details of new plastic condenser and heat exchanger tube protectors.

356 Tubing, metal, inflatable. Technical data from Calumet & Hecla on new light-wall metal tubing that can be shipped in ribbon form and inflated at point of use.

357 Tubing, pressure, carbon steel. Bulletin TDC-142B from Babcock & Wilcox gives data on mechanical and physical properties of seamless and welded carbon steel pressure tubing.

358 Tubing, titanium alloy. Newly-developed alloy fabricates as readily as unalloyed titanium yet approaches stainless steel in tensile strength. Info from Superior Tube.

359 Valves. New 190-page Bulletin A-155 from Associated Valve gives complete data on line of valves for chemical and nuclear applications.

360 Valves, control. Catalog 789-59 from Whalen gives details of control valves for working pressures to 15,000 lb./sq. in.

361 Valves, diaphragm, sliding-gate. Bulletin J-170 from OPW-Jordan gives dimensional drawings, flow capacities, rating charts, sample specifications.

362 Valves, gate, pressure-sealing. New line available in sizes from 2 to 30 in., in ASA 150 and 300 lb. classes. Data from ACF Industries, W-K-M Div.

363 Valves, jacketed. All sizes and types of Parks-Cramer semi-steel and steel jacketed pipe, valves, and fittings, now available lined with Kel-F halofluorocarbon resin. Technical info.

364 Valves, plug, coated. Bulletin V-614 from Rockwell Mfg. describes plug valves specially coated with K51 (Penton), Kanigen, and Teflon. Tables of recommended specifications, typical applications.

365 Valves, temperature-control. Sliding-gate, self-operated temperature control valve is rated for temperatures from 35 to 450°F, pressures to 250 lb./sq. in. Data Sheet SRB 18-59 and Bulletin J-10 from OPW-Jordan.

366 Venturi Tubes, fabricated. Bulletin 402-A from Burgess-Manning gives technical details, includes complete capacity table.

367 Venturi Tubes, insert-type. Bulletin 401-A from Burgess-Manning shows construction details, dimensions, has complete capacity table.

368 Vessels, pressure. Brochure from Solar Chicago, Div. of U. S. Industries, gives specifications of many types of vessels, describes fabricating techniques and facilities.

369 Vibrators, electric. For free feeding of bulk materials through bins, hoppers and chutes. Bulletin from Syntron.

Materials *from page 100*

384 Metholene Esters. New Technical Bulletin on "Metholene Esters for Alkyloamides" from Emery Industries.

385 Organic Chemicals. New 200-page Catalog from Matheson lists over 4,500 items, including organic chemicals, laboratory reagents, solvents, biological stains.

386 Packings, Teflon. Bulletin from Flexrock gives specifications, properties of several types of Teflon packing.

387 Porous Nickel, sintered. Data from Corning Glass on new pressed and sintered porous nickel, capable of operating at temperatures to 575°F.

388 Pyroceram. Progress Report from Corning Glass gives electrical, mechanical, thermal, chemical properties of new glass-ceramic, features comparative property chart.

389 Sealers. Reference Chart from Benjamin Foster Co. tabulates selection data on flashing compounds and joint sealers.

390 Molecular Sieves, chemical-loaded. Linde (Union Carbide) offers 7 Technical Bulletins on properties and current uses of chemical-loaded molecular sieves.

391 Silicone Rubber, solvent-resistant. Technical data from Dow Corning on what is said to be first fuel and solvent resistant silicone rubber masterbatch, Silastic LS-422 Base.

DEVELOPMENT OF THE MONTH

PLANETARY MIXER-DISPERSER

(Circle 602 on Data Post Card)

A new heavy-duty vertical planetary mixer, made by Bramley Machinery, features safety provisions for production of solid propellants and other hazardous materials. The unit, which has a capacity of 250 gallons, is 14 feet high and is powered with a 4-speed, 20 hp, explosion-proof motor.

The mixing chamber is jacketed around the periphery, including the bottom, for either cooling or heating. Allowable internal working pressure is 50 lb./sq. in. A separate hydraulic system raises the mixing chamber and holds it to the head, permitting the mixing operation to be conducted under high vacuum.

All gears, bearings, other moving parts are isolated from the batch being mixed to avoid contamination of the material. For more technical data, Circle 602 on Data Post Card.

392 Sulfur Trioxide, stabilized. Du Pont offers Bulletin on liquid sulfur trioxide featuring newly-developed stabilizer.

393 Waxs, sugar cane. Special Laboratory Report from Western Petrochemical on "Cane Wax Aids" gives data on use of sugar cane waxes as rubber processing aids.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.

PROFIT

from the savings afforded by

interchangeability

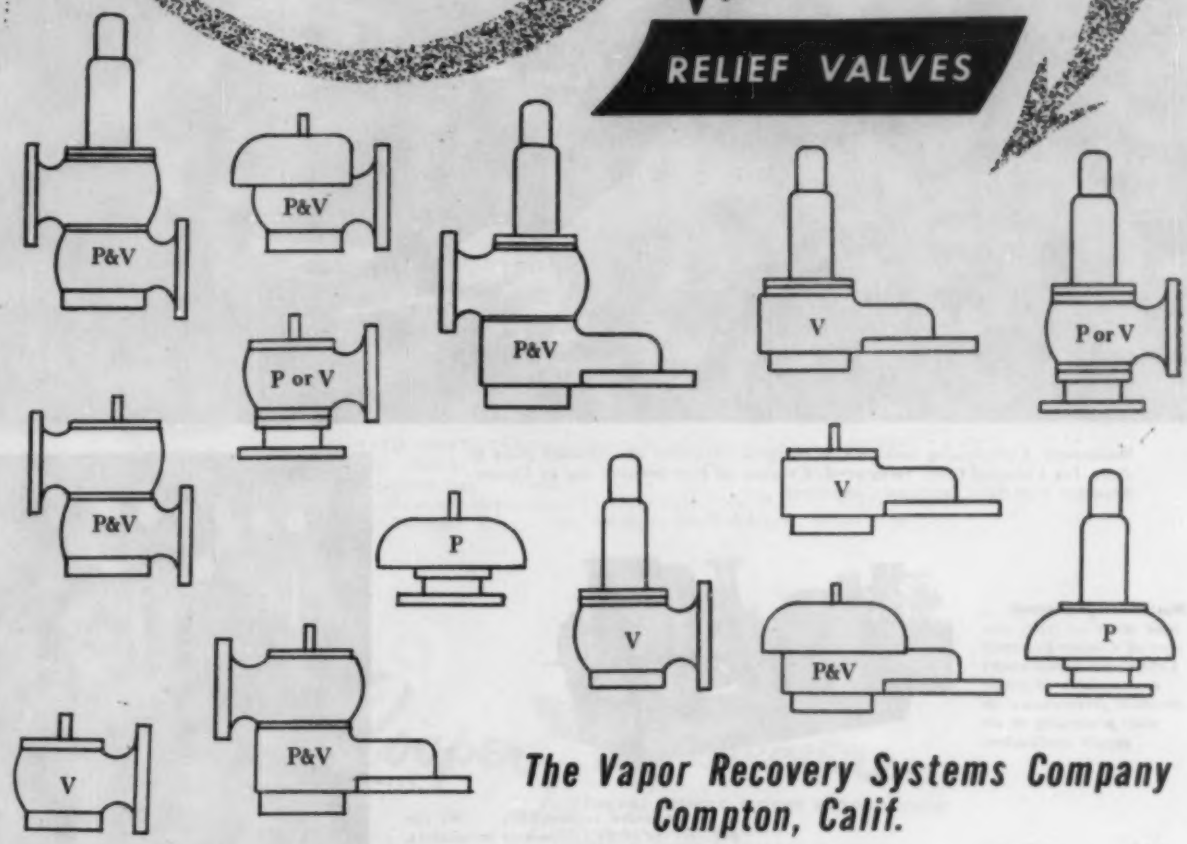
5 BASIC CASTINGS

Your choice of any castable material

The arrangement of two or more basic castings with the proper internal parts allows a selection of FOURTEEN DIFFERENT STYLES of PRESSURE, VACUUM, and COMBINATION PRESSURE AND VACUUM relief valves. Castings may be rotated in relation to each other when assembled to accommodate any ANGULARITY of valve piping.

"Varec"

RELIEF VALVES

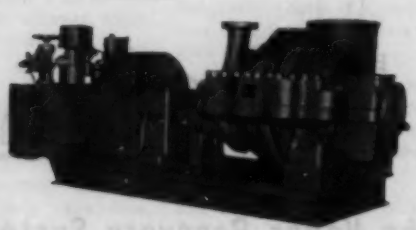


The Vapor Recovery Systems Company
Compton, Calif.

For more information, turn to Data Service card, circle No. 94

Background: *Compressing isobutane in refrigeration-system of alkylation plant of Petro-Tex Chemical Corp.* **Foreground**: *Cutaway of high-pressure seal of Cooper-Bessemer Type RD Centrifugal Compressor.*

Matched to your needs . . . *A wide range of types and sizes of Cooper-Bessemer Centrifugal Compressors are available to assure optimum performance on your processing or air supply application.*



Undivided responsibility . . . *We can engineer the entire compressor installation, including drive and controls* ***Cooper-Bessemer En-Tronic® Controls*** provide any degree of automation

John Fullemann, *Chief Turboproduct Design Engineer, and* Kenneth Stevenson, *Turboproduct Designer, The Cooper-Bessemer Corporation, discuss...*

How reliable Cooper-Bessemer Centrifugal Compressors aid 'round-the-clock processing

For example, here's the picture at Petro-Tex Chemical Corp., Houston: The entire sulfuric acid alkylation plant banks on the dependable performance of the Cooper-Bessemer Type RD Centrifugal Compressor which handles isobutane for refrigeration. This unit operates on a continuous, 24-hour basis, handling 11,125 cfm and boosting pressure from 16.2 to 98 psia. Its constant availability is a must.

Of course, many things go into Cooper-Bessemer centrifugals to assure this kind of reliability. For example, take the two-sleeve oil film type seals shown in the illustration. This Cooper-Bessemer design is capable of sealing against pressures of more than 1000 psi, for utmost dependability in processing service.

Bear in mind, too, that the performance of Cooper-Bessemer equipment is backed by an unsurpassed service organization to help protect your plant investment and assure optimum operating economy. For further information, call our nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Chicago Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston Greggton • Dallas • Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles

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C-B Southern, Inc.... Houston
Cooper-Bessemer International Corporation... New York • Caracas • Mexico City
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ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

For more information, turn to Data Service card, circle No. 83

Problem: The manufacturers of Tyrex, the revolutionary new tire cord, had a real problem: A pipe to transport highly corrosive liquids at extremely high temperatures.

TYREX

Answer: After extensive exploring, investigating, checking and testing, they found the **Fibercast® NON-CORROSIVE PIPE and FITTINGS**

The proven fact that Fibercast will not corrode is in itself justification for its use by the makers of Tyrex. But there are other important time- and money-saving benefits. For example:

Takes high temperatures — up to 300° F . . . *High operating pressures* — to 1000 p.s.i. . . . *Light and easy to handle* — being less than ¼ the weight of steel, requires a minimum in manpower and equipment for installation . . . *Pre-fabricating Service* — In many systems, pre-fabrication of assemblies at the factory by Fibercast specialists, working from your prints, with installation by your plant personnel, will be more practical and economical.

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☐ Send your new Data and Information Bulletin No. 20.
☐ Full information on your Pre-fabricating Service.

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Company _____
Address _____
City _____ State _____

For more information, turn to Data Service card, circle No. 115

industrial news

A $6 million carbon black plant, with production facilities for over 60 million pounds annually, will be built near Milan, Italy, by Columbian Carbon. The new firm, which will manufacture three grades of carbon (two tread blacks and one carcass black is said to be the largest initial carbon black facility embodying modern American designs to be built in Europe. Part of an over-all expansion policy on the part of the parent firm, the company will function under the name of Columbian Carbon Europa.

Gum rosin production goes ahead in Mexico with the formation of a company by one of Mexico's largest naval stores producers, Resinera Uruapan S. A., and Heyden Newport. The new company, Resinera del Tigre S. de R. L. de C. V., will build a plant in the Guadalajara industrial area. Heyden Newport, through its International Division, expects to export gum rosin for both RUSA and the new firm by the end of 1959. Plans are to follow with a line of derivative chemicals stemming from rosin and turpentine.

Plastic model of a reactor used to study flow of gases through packed beds is shown to three officers of Penn State's A.I.Ch.E. chapter by Sun Oil's Bob Matteson. (l. to r.) Matteson, George Fish, chapter president; Richard Klinger, vice president; and Ross Kremer, secretary. They were part of a tour group of 44 students who visited Sun's research and development laboratories at the Marcus Hook, Pa., refinery.

A British company just established to produce nuclear-grade beryllium metal and beryllium-copper master alloy, will sell the raw material to fabricators in England and Europe. Said to be the first operation of its kind in the United Kingdom, the new company, Consolidated Beryllium, is to be managed by Imperial Smelting, London, co-owner along with Beryllium Corp, Reading, Pa. Date for construction has not been set, although design work is in process.

Complete SCOPE of
WATER CONDITIONING
SERVICE from...

ALLIS-CHALMERS

End algae problems

easy, low-cost way

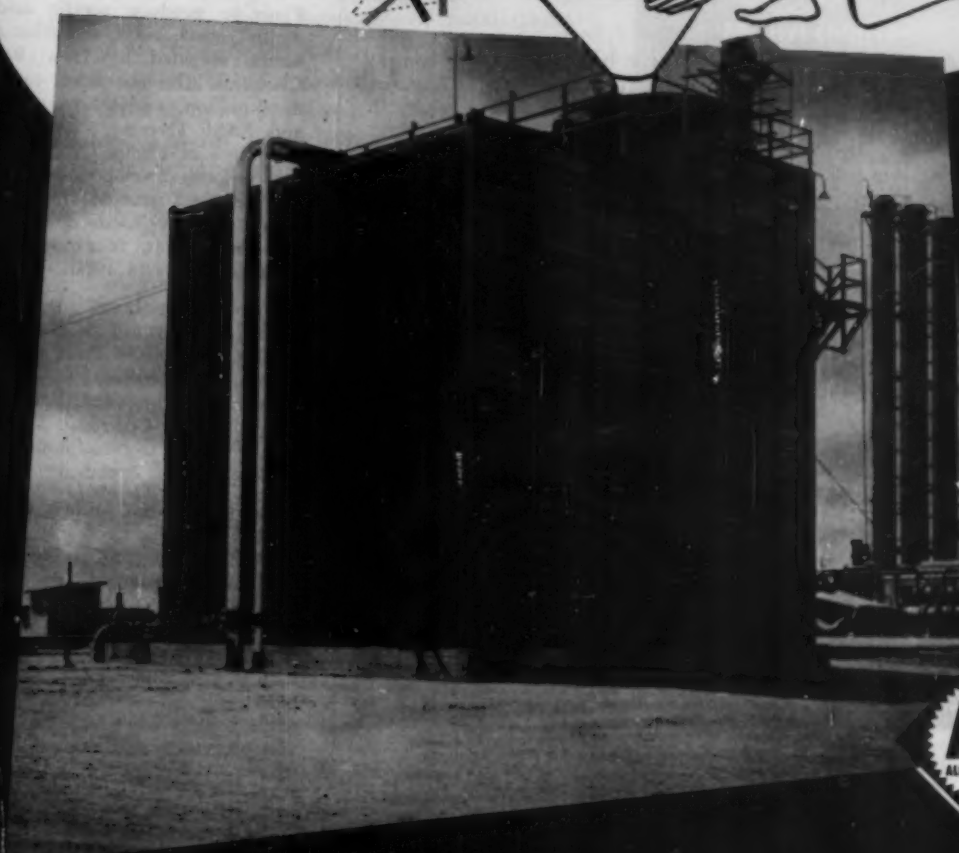
Eliminate problems of plugged pump strainers, coated heat-exchanger tubes and coated slots in cooling towers.

Control is safe . . . quick with Allis-Chalmers No. 120 Series Algaecide.

This algaecide is toxic to more algae than any other. On the other hand, it has low toxicity to fish or animals and is extremely safe to handle. Even in concentrated form it is only a mild irritant to skin and hands.

A little goes a long way! Only 2 to 5 ppm are required for effective dosage of most organisms. It's easy to feed into the system . . . and is non-oxidizing and corrosion inhibiting.

No water conditioning specialist needed to use it! Buy it and try it. *Purchase directly from your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.*



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Specify Aerofin and you specify high efficiency, long service life and low maintenance and service costs.

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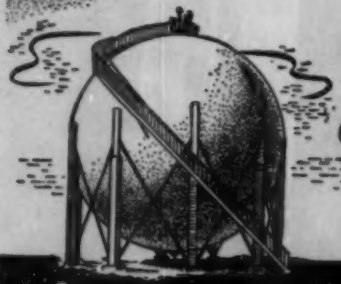
* *Aerofin makes extended heat surface exclusively — not as a by-product, not as a side-line.*



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For more information, turn to Data Service card, circle No. 18

industrial news

A crude distillation unit has gone on-stream at Shell Haven, England, almost doubling the refinery's capacity. The new unit, which brings total output to 160,000 barrels daily, represents an investment of approximately $18 million. Special features of the plant are high degree of heat recovery, resulting in about 30 percent lower fuel consumption; recovery of light hydrocarbons, obtained by use of a large high speed centrifugal compressor. The plant was designed by Stone & Webster, in collaboration with Shell technologists in Holland.

Two additional chemical process plants have been approved for construction by the Japanese government. A $6 million synthesis gas production plant for Nitto Chemical, will eventually produce 125 tons a day of synthetic ammonia. Another plant to produce butanol and octanol from petroleum naptha, will be built for Kyowa Industry, Ube, Japan. Both projects will be designed and constructed under a technical assistance agreement between Iino Shipbuilding & Engineering, Tokyo, Japan, and Tears Engineers, Dallas, Texas.

Plans to produce acrylic acid and methyl, ethyl, butyl, and other acrylic esters, revealed by Dow Badische Chemical. The company, capitalized at $6 million, is jointly owned by Dow and BASF Overzee, N.V., Badische subsidiary of Rhein, Germany. A direct process developed by Badische, and believed new to the American scene, will be used. The plant at Freeport, Texas, is expected to go on-stream early in 1960.

Sales of the combined enterprises are expected to exceed $225 million in 1959. Operations of the Victor organization, which remains intact, will be carried on as the Victor Chemical Division, Stauffer Chemical. The merger plan is shortly to be submitted to the stockholders for approval.

Ground has been broken on Foster Grant's $1 million research center at Leominster, Mass., an expansion which will increase company research and development facilities by 50 percent. Work will be concentrated on improving the durability and versatility of regular and high impact polystyrene, nylon 6 and styrene acrylonitrile, while basic studies on new polymers and processing methods continue.

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Chempump, the original "canned" pump, handles them all easily.

If you've got a problem handling volatile, toxic, explosive or other "tough" fluids, Chempump is your answer. This process-proved, maintenance-free pump can handle the tough ones with absolutely no leakage or contamination. Units available for system pressures to 5,000 psi . . . temperatures to 1,000 F. . . . capacities to 600 gpm.

Here's a pump that is built to a design evolved from years of experience in the "canned" pump field . . . many more years than any other manufacturer of similar pumps.

Only Chempump offers you proved operating performance . . . from thousands of installations in all types of services . . . plus experienced field sales engineering. Use Chempump to solve your fluid pumping problems. Write now . . . for "request for quote" data sheet . . . to Chempump Division, Fostoria Corporation, Buck and County Line Roads, Huntingdon Valley, Pa.

- Acetic acid
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- Heavy water
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- Sulphite liquors
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- Nitrogen tetroxide
- Hydrazine
- Formaldehyde
- Boron fuels
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- Mercaptans
- Ethylene oxide

Chempump combines pump and motor in a single, leakproof unit. No seals, no stuffing box. Most models U. L. approved.

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Finest in the field...*process proved*

For more information, turn to Data Sevice card, circle No. 64

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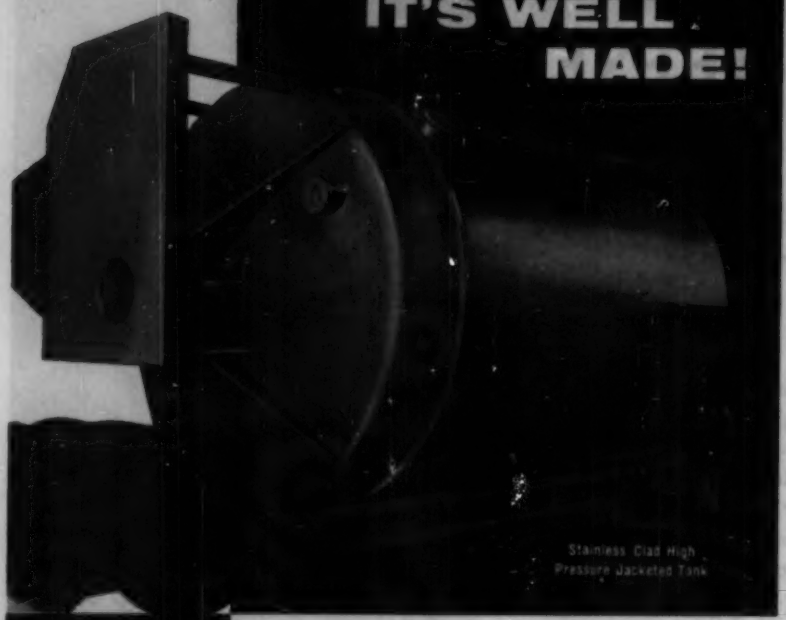
IT'S WELL MADE!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For more information, turn to Data Service card, circle No. 95

industrial news

Facilities for manufacture of high impact and conventional polystyrene to be built at Joliet, Illinois, by Amoco Chemicals, include both large-scale commercial and product development plants. The operation, using a process developed by Standard Oil, Indiana, is expected to be in full swing by late 1961.

Expansion in maleic anhydride facilities will take place at Reichhold Chemicals when a new $4 million plant is built. The facility, adjacent to RCI's plant at Elizabeth, N. J., will have a capacity of 20 million pounds a year. Plans call for it to go on-stream in June, 1960.

Another entry on the high energy rocket fuel scene is National Research, which teamed up with Aerojet-General on new missile fuel development. Under an agreement between the two, Aerojet gets exclusive U.S. patent rights for vacuum processes, equipment and techniques developed by National Research. Eventual commercial production of solids propellant ingredients is visualized.

A corporation manufacturing and selling valves for pipelines in France and its colonies is in operation at Soissons, France. Work proceeds on orders from French oil companies for the Tunisian pipeline from Edgerlé field in the Sahara. Organized by Walworth, New York, the firm's authorized capital is 60 million francs.

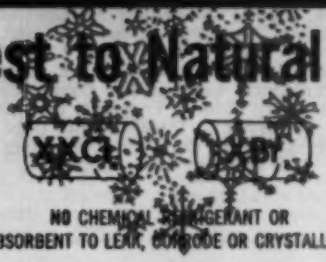
Synthesis of certain chemicals for testing under the anti-radiation program of US Army Research & Development Command will be investigated under a research contract awarded Michigan Chemical. Work has already started at the company's lab in St. Louis, Michigan.

A new grouping formed Armour Industrial Chemical, includes the fatty acids, fatty nitrogen derivatives and ammonia divisions of Armour & Co. Offices are in Chicago.

An expansion in ethylene capacity by 75 million pounds a year will take place at the Sweeny, Texas plant of Phillips Chemical (Phillips Petroleum) by the end of the year, according to present plans. This brings the total capacity to 255 million pounds. Ethylene produced at Sweeny goes to make rigid polyethyenes (tradenamed Marlex), as well as to other polyethylene manufacturers in the area.

Comes Nearest to Natural Refrigeration

Nature produces refrigeration (snow, sleet, and hail) indirectly by change of atmospheric pressure to bring warm water vapor in contact with cold air.



In each case, water is its own refrigerant or cold air serves the purpose. Jet vacuum refrigeration comes nearest to this natural refrigeration.

As a method of industrial refrigeration, jet vacuum refrigeration is thoroughly established and is successful in many hundreds of industrial plants in capacities varying from a few tons to 4500 tons.

The unit sketched can be placed outdoors and operated continuously or intermittently in any climate. The equipment adapts itself readily to automatic control or is very easy to control manually. The unit is self-supporting. There are no moving parts, no noise, no vibration. The maintenance and supervision required are negligible.

While most vacuum installations are used to cool water, vacuum cooling is particularly efficient for cooling chemical solutions. Instead of the usual expensive heat transfer surface, only simple corrosion-resistant vessels are needed. Some process plants have dozens of separate units totaling thousands of tons of refrigeration just for the purpose of cooling chemical solutions. Their record of savings is remarkable.

There are many other applications, too. Fresh vegetables and other moist solids are readily cooled by jet vacuum refrigeration. By adding a heat exchanger bundle inside the vacuum chamber, gases can be cooled without circulating any liquid. In some cases, the automatic de-aerating effect of vacuum cooling is important.

Many installations of old style mechanical refrigeration could be replaced profitably with vacuum refrigeration, which costs much less to buy and somewhat less to operate.

All inquiries will be given careful engineering study without obligation.

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For more information, turn to Data Service card, circle No. 73

Candidates for A.I.Ch.E. Offices

Here are the brief biographical sketches and records of accomplishment of the candidates for the 1959 A.I.Ch.E. national elections. Candidates have been chosen by the Nominating Committee (members listed on the next page) unless otherwise designated as nominated by petition. Space does not permit the presentation of full details of these men's careers, and additional details of their education and career are available on request from the Secretary's Office. Further nominations by petition may be accepted until October 5, and any received will be announced with brief biographical data in the next available issue of CEP. Ballots will be mailed from the Secretary's Office in October.

. . . *nominated as officers for 1960*

PRESIDENT

JERRY McAFEE—Industrial Executive. Vice-pres. ('55-) Mfg. Dept., Gulf Oil. Res. Chem. eng. ('40-'45) Universal Oil Products; tech. specialist ('45-'50) Gulf Oil (Port Arthur); Dir. Chem. Div. ('50), asst. dir. rsch. ('51-'53), vice-pres. & assoc. dir. rsch. ('54-'55), Gulf R. & D. Co. Also presently vice-pres. of Venezuela Gulf Ref. Co., Dir. Gulf R. & D., Dir. Goodrich-Gulf Chem., Dir. Neches Butane Products, Dir. Callery Chem. Holds 13 U.S. Patents. Author or co-author of numerous technical publications. **AIChE:** vice-pres. ('59); Dir. ('56-'59); chmn. ('59) Secs. Acts. Comm.; chmn. ('58) Prof. Dev. Comm.; Nominating Comm. ('57); Housing Comm. ('55-'56). Active in Pittsburgh Section, chmn. ('54-'55). Member of API and a U.S. representative on the Permanent Council of the World Petroleum Congress, helped organize 5th World Petr. Congress.

TREASURER

J. HENRY RUSHTON — Educator, consultant, Past-President and Treasurer ('58-) of A.I.Ch.E., Prof. chem. eng. ('55-) Purdue. Consultant, Dept. of Defense, A.E.C. firms in petrol. & food indust.; tech. advisor, Mixing Equip. Co.; Prof. & dept. head ('37-'46), U. of Va.; prof. & dir. of dept. ('46-'55), Ill. Inst. Tech. Author: mixing scale-up, low-temp. operations, others. **A.I.Ch.E.:** President ('57), vice-pres. ('56), Dir. ('52-'54); chmn. Local Sect. Activ. Comm.; has been chmn. Student Chapters, Projects, Future of Inst. Comms. Chicago Sect. dir. ('52-'55). Walker Award ('52). Mbr. A.S.E.E. (past mbr. Council, secy. ad hoc Comm. on Eval. Engrg. Educ.); Engineers Council for Professional Development (mbr. Educ. & Accred. Comm.); N. Y. Chemists' Club (past non-res. v.p.).

SECRETARY

F. J. VAN ANTWERPEN — Secretary and Executive Secretary of A.I.Ch.E. ('55-). Publisher and bus. mgr. ('46-) A.I.Ch.E.; editor of CEP ('47-'55). **A.I.Ch.E.:** Founder of New Jersey Section; Awards Comm. ('47-); Hist. of the Institute Comm. ('53-'55); secy., 50th Anniv. Comm. ('55-'58); Admissions Comm.; Finance Comm. ('55-); Nuclear Energy Comm. ('52-'57); Program Comm. ('47-); Publications Comm. ('47-); Public Relations Comm. ('44-'55), chmn. ('44-'47); Standard System of Symbols and Nomenclature Comm. ('47); EJC Committee of Secretaries; Member-Giving Committee for the UEC; AEC Advisory Committee on Industrial Information; member ASEE ('56); EJC-Atomic Energy Panel ('55-'56); American Documentation Inst. ('55-'57); Who's Who in Engineering; Co-author of History of the Institute. Author of technical articles.

VICE-PRESIDENT

J. J. HEALY*—Industrial Executive. Member of the Corporate Planning Group, Monsanto Chemical Co. ('58-); Merrimac Chem. Co. ('21-'29); Monsanto Chemical Co. ('29-). Asst. to vice-pres. Research, Devel. & Engineering ('51-'56), Dir. of Development of Rsch. and Engineering Division ('56-'57), Monsanto Chemical Co. In his present position on Monsanto's Corporate Planning Group, he is responsible to the president for all phases of long range planning for the company. **A.I.Ch.E.:** Dir. ('48-'50) and ('57-); chmn. ('48-'50) Local Sections Committee; Institute Representative on Engineering Manpower Commission ('54-'57); Nominating Committee ('57-'58); Constitution & By-Laws Committee ('56-); Admissions Committee ('44-'49); active in local sections, was chmn. ('35) Boston Section. ***Also nominated by petition.**

W. R. MARSHALL, JR. — Educator, consultant. Assoc. Dean, College of Engineering, Univ. of Wisconsin, and Assoc. Director, Engineering Exp. Station, Univ. of Wisconsin. E. I. du Pont ('41-'47); Assoc. Prof. ChE. ('47-'53) Univ. of Wisconsin; Professor and Assoc. Dean ('53-), Univ. of Wisconsin. Consultant to industry in drying, atomization, heat and mass transfer, and related topics. Co-author of text illustrating applications of differential equations to chemical engineering problems; author of Drying section in Perry's Chemical Engineering Handbook; author or co-author of over 30 technical papers. **A.I.Ch.E.:** Dir. ('56-'58); served on Equip. Testing Procedures Comm., Program Comm., Standards Comm., and Awards Comm.; best presentation award at 1950 Annual Mtg.; Institute Lecturer ('52); Walker Award ('53).

WALTER E. LOBO * — Engineering consultant ('58-). Various engineering and supervisory capacities ('29-'39), Dir. Chem. Eng. Div. ('39-'57) M. W. Kellogg; Lecturer Columbia Univ. ('39-'41); tech. consultant ('44-'46) N.D.R.C.; cons. ('56-'57) Army Chem. Corps; Author of various articles on heat trans., furnace design, distillation, tonnage oxygen, process design; holds 14 U. S. patents; lic. prof. eng. N. Y., N. J., Ohio. **A.I.Ch.E.:** Dir. ('55-'57); chmn. Tech. Progr. Comm. White Sulfur Springs, ('51). Prog. Comm. ('47-'52), chmn. ('50-'52); chmn. ('56-'57) Const. & By-Laws Comm.; Awards Comm. ('48-'51); chmn. ('50-54) Res. Comm.; Publ. Comm. ('46-'52); chmn. ('57) Founders Award Comm.; AIChE Trustee-UET ('57-'62); Fin. Comm. ('58); EJC: Dir. ('55-'57), Exec. Comm. ('55-), Chmn. Fin. Comm. ('56 & '59). ***Nominated by petition.**

. . . . . *nominated as directors for three-year term beginning 1960*

WILLIAM E. CHALFANT—Industrial Executive, Ass't Mgr. ('56-) Product Control Dept., Atlantic Refining Co. ('56-); pilot plant res. ('35-'45); tech. asst. to plant mgr. ('45-'50); asst. to vice-pres. ('51); asst. supt. Chem. Mfg. ('52-'56); chmn. Sub-Comm. of Petrol. Indus. War Council ('42-'44). Numerous classified publ. on mfg. petroleum products for war. **A.I.Ch.E.:** Genl. chmn. 50th Anniv. Jubilee ('58); chmn. ('52-'53), Sec. repres. Philadelphia Engineering and Technical Societies Council ('54-'56). Philadelphia-Wilmington Section. Executive Committee, Annual Meeting ('51).

DONALD A. DAHLSTROM*—Industrial executive and educator. Director of Research & Devel., The Eimco Corp. ('53-). Petroleum & chemical engineer ('42-'45) Int. Petroleum Co. (Peru); Inst., asst. prof. & assoc. prof. ('46-'56) Northwestern U. Author: Technical articles contributed to over 17 publications. **A.I.Ch.E.:** Advisory board of CEP; assoc. chmn. ('57) Chicago Annual Mtg.; tech. prog. chmn. ('52) Chicago National Mtg.; Committees — Pollution Control Engineering, UEC Fund Campaign, Program Committee; director-at-large, Chicago Section; member of several committees in Chicago Section; former advisor, student Chapter, Northwestern. ***Also nominated by petition.**

HOWARD L. MALAKOFF—Industrial executive, educator. Manager, Development Dept., Petroleum Chemicals. Instructor ('37-'41) Carnegie Tech.; asst. prof. ('41-'43) Oklahoma A & M; chem. eng. ('43-'45) Nat. Gasoline and Chem. Div., eng. section chief ('45-'48), Cities Service Oil Co.; tech. asst. to Dir. of Rsch. ('48-'54) Cities Service Rsch. & Devel.; staff admin. asst. ('54-'56) Cities Service Peroleum. **A.I.Ch.E.:** Gen. Chmn. ('55) Annual Mtg. in New York; Tech. Prog. chmn. ('61) New Orleans National Meeting; former chmn. Research Comm.; Program and Local Section Committees; chmn. Oklahoma and New York City local sections.

KARL H. HACHMUTH* — Industrial executive. Engineering advisor to vice-pres. Rsch. & Devel. ('59-), Phillips Petroleum. Asst. devel. chemist ('26-'27) Ozokerite Mining Co.; rsch., engineer ('27-'35), section chief ('35-'43), assoc. dir. of rsch., Engineering Div., Rsch. Dept. ('43-'46), tech. consultant ('46-'50), member rsch. training board ('50-'59), Phillips Petroleum; tech. advisory comm., chmn. ('52-), Fractionation Rsch., Inc. More than 40 U. S. patents. Author of many technical articles. **A.I.Ch.E.:** chmn. ('59-) Rsch. Comm.; National Program Comm. ('58-); tech. prog. chmn. for 1960 Tulsa Meeting. ***Also nominated by petition.**

W. K. MENKE—Industrial executive. Vice president, Chemical Division, ('52-), Pittsburgh Coke and Chemical Company. Chemical engineer, plant operations ('35-'39), in Engineering Development Department ('39-'42), in Technical Development Department ('42-'50), director of General Development ('50-'52), Monsanto Chemical Company. **A.I.Ch.E.:** organized first student chapter at Washington University in St. Louis ('32); long active in local section work, was a member of the St. Louis section ('35-'52); now member of admissions comm., Pittsburgh Section.

NORMAN MORASH*—Industrial executive. Supervisor, Devel. & Engineering Dept., Titanium Div. ('50-) National Lead Co. Special projects engineer, Calco Chemical Div., and group leader, Development Engineering Dept., American Cyanamid Co.; plant development engineer, Phosphate Rock Mines, American Agricultural Chemical Co. Holds many U. S. Patents, has authored many technical articles. **A.I.Ch.E.:** asst. chmn. ('59-) Adm. Comm.; asst. chmn. ('59-) Program Comm.; Program chmn. Atlantic City meeting ('59); A.I.Ch.E. Liaison to Process Industries Div. of ASME; charter member New Jersey Section. ***Also nominated by petition.**

CARL F. PRUTTON—Industrial executive and educator. Executive vice-pres., Chemical Divisions, Food Machinery & Chemical. Inst. ('20-'25), asst. prof. ('25-'29), assoc. prof. ('29-'35), prof. head of Ch.E. Dept. ('36-'48), Case Inst.; chief, Process Devel. Brnch. ('42-'44), Office of Rubber Director; cons. ('28-'41) Dow Chem.; cons. ('29-'51) Lubrizol Corp.; dir. of rsch. ('48-'49), vice pres. ('49-'53) Mathieson Chem.; vice pres. & tech. dir. ('54-'56) Chemical Divs., FMC. Over 100 patents for lubricants and chemical processes. Author of numerous technical papers. **A.I.Ch.E.:** chmn. of Cleveland National Meeting; former chmn. Cleveland Section.

CHARLES R. WILKE—Educator and consultant. Prof. and chmn. of Chemical Engineering Dept. ('53-), Univ. of California. Chem. eng. ('44-'45) Union Oil Co. of Calif.; instructor ('46), asst. prof. ('47), assoc. prof. ('51-'53), Univ. of California. Consultant ('50-) Univ. of Calif. Radiation Lab.; ('52-) Union Oil Co. of Calif.; ('57-) Monsanto Chem.; ('58-) Reinhold Publ. Corp. Author of technical articles on transport properties and mass transfer. **A.I.Ch.E.:** Institute Lecturer ('57); Junior Award ('51); Tech., Prog. Chmn. ('59) San Fran. Nat. Meeting; Student Chap. Comm. ('51-); Prog. Comm. ('52-), chmn. Div. 1 ('56-); Rsch. Comm. ('59); chmn. ('53) North. Cal. Section.

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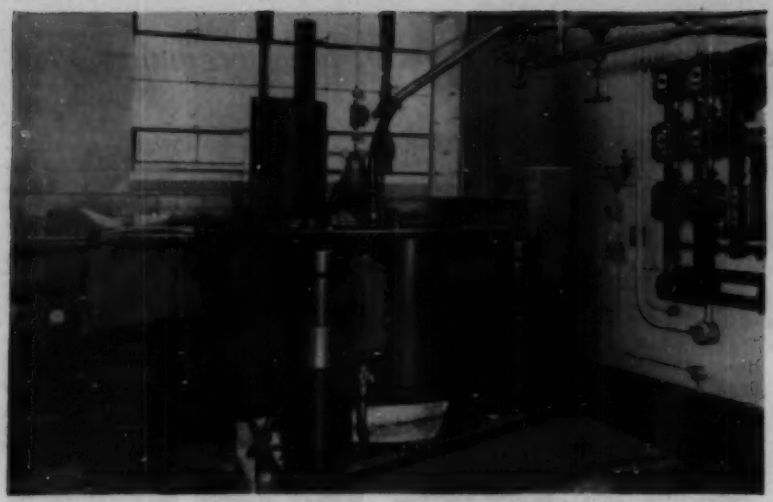

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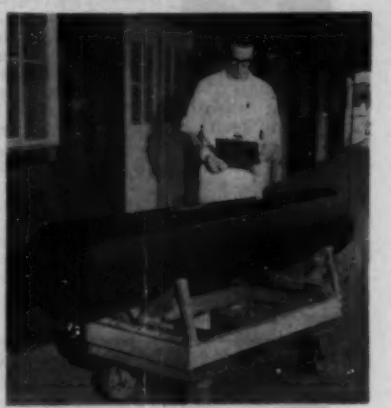
industrial news

A two-year research study of chemical reaction kinetics will be undertaken at Syracuse University under a $20,000 grant from the National Science Foundation. The project, conducted by the Chemical Engineering Department, is expected to contribute significantly to the general understanding of chemical reactions in gas-liquid systems.

A multi-purpose chemical unit added to Phillips Chemical (Phillips Petroleum) Philtex plant near Borger, Texas, consists of several facilities whose operations may be combined in various ways to produce a number of small-volume specialty chemicals. The unit will enable the company to further upgrade hydrocarbon feedstocks it produces in the area. It can also be used as a pilot plant.

A 50 percent expansion in production facilities for styrene-butadiene latex (tradenamed Gen-flo), just completed by General Tire & Rubber, at its Mogadore, Ohio plant. Additional facilities include a glass-lined reactor system, also provide for production of styrene acrylic latex.



Uses of an advanced solid propellant for the Nike Zeus missile will be explored by Olin Mathieson. Under an army ordnance contract, work will be carried on by the Energy Division, near Marion, Illinois. The new propellant will be made by a continuous mixing process developed by the company.

Construction has begun on Montecatini's $10 million isotactic polypropylene plant at Neal, West Va. Capacity is estimated at 10 million pounds annually, subject to revision upward as the project proceeds. Operation of the company's first American venture will be by Novamont Corp., Montecatini subsidiary.

An Important Message

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Samples of metals for testing are available upon request; arrangements can be made for the loan of certain equipment for pilot operations or heat transfer studies.

More tantalum equipment engineered and fabricated by Fansteel is in use today in a greater diversity of chemical processes than at any time in history. This equipment includes heat exchangers, evaporators, stills, condensers, coils, bayonet heaters, instrument protection—all used under extremely corrosive conditions where long equipment life, freedom from product contaminations and undesirable side reactions make the use of tantalum a necessity.

Fansteel is properly proud of this contribution to the chemical industries, a contribution, indeed, which has been recognized by several national awards.

However, it is not enough merely to attain a position of leadership; it must be kept. And Fansteel has taken these steps to be of greater service to our chemical industry customers:

Tantalum Plentifully Available. As you read this, the tantalum production at both our North Chicago and Muskogee, Oklahoma plants is at record levels. Short of total war, there will always be an ample supply of tantalum for chemical equipment.

Improved Delivery Service. New equipment has been added in our fabrication shops, particularly equipment for improved welding. Tapered tantalum condensers (Cat. No. D-4538) are presently stocked for immediate delivery. A stock of tantalum bayonet heaters, in several sizes, will also be available soon.

One Integrated Responsibility. Fansteel is the one supplier of tantalum equipment who performs the entire job—produces the metal from the ore, engineers the application, designs and builds the suitable equipment. With Fansteel, there can be no divided responsibility.

Other Materials of Construction. Fansteel is fabricating equipment from other materials of construction, such as columbium, molybdenum, tungsten, zirconium and titanium. While these metals are not as highly resistant to corrosion as tantalum, they all have desirable properties for chemical processes applications.

Engineering and Design. Fansteel is always ready to undertake the task of converting your problem into a reliable piece of equipment, when it comes within the scope of our materials and experience. This means that we will design and fabricate the equipment and, if desired, assist in installation.

SINCERELY,

Fred H. Diggs
PRESIDENT

Address your inquiries to Equipment Department, Metals Fabrication Division

Q592

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FANSTEEL

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equipment feature

Maintenance of Grinding Equipment

A. J. Tenner
Safety Industries, Entoleter Division
New Haven, Conn.

Proper maintenance is basically the detecting or elimination of a situation that may eventually lead to equipment breakdown

Particle size reduction equipment can generally be considered as consisting of three components: the power element such as a motor; the power transmission element such as a belt or chain drive; and the equipment elements that actually perform the size reduction.

Most particle size equipment today is driven by an electric motor: in general, manufacturers are providing motors that perform quite adequately under the most adverse conditions. It is, however, advisable to use motors which have provision for the complete change of bearing lubrication, so that, periodically, all the grease lubricant can be flushed through the motor ball bearings and new lubricant added. This is of particular importance when the motor is required to run in dusty or corrosive atmospheres.

Breathing of bearings

One of the biggest problems in maintaining bearings, whether on the motor or on the size reduction equipment proper, is the so-called "breathing" of a bearing. The breathing occurs when the rotating unit has run for a sufficient period of time so that the lubricating grease has reached its normal operating temperature. When the unit is shut down and the lubrication is cooling, it will, even if properly sealed, inhale some of the surrounding atmosphere. When this atmosphere contains either dust or corrosive elements, the resulting contamination can result in the shortening of bearing life.

In equipment having high-speed rotating elements, sealing can pose a serious problem, due not only to the high cost of such seals, but to the close tolerances which must be met in their fabrication. In some situations, use of an air-oil mist lubrication has been quite successful, since this method of lubrication places the bearing housing under a positive pressure. Since this positive pressure can be maintained even when the unit is shut down, the system completely prevents foreign particles from entering the housing from the atmosphere.

Driving systems

Use of V-belt drives necessitates careful observation to see that a minimum number of belts may be kept on hand as spares. Many companies, through experience and standardization of practices, have set up a maintenance schedule in which belts on equipment are replaced periodically. If this schedule is properly set up, it has been found possible to eliminate any failures due to breaking or fraying of belts during operation.

Maintenance of chain drive systems is chiefly a matter of proper lubrication. However, recent advances in powder metallurgy have opened up the possibility of impregnating roller chain parts with lubricant material, thus eliminating regular lubrication schedules.

Grinding elements

In processes for particle size reduction of materials that are neither abrasive or corrosive, grinding elements do not generally offer any substantial problem. In most actual cases, however, the product will be either abrasive or corrosive, or a combination of both. In order to gain sufficient wear life, it is becoming more and more necessary to fabricate equipment with more exotic and expensive materials.

When wear life is insufficient, all that may be required is a slight change of materials, such as a switch from carbon to stainless steel. In many cases, however, such a simple remedy will not solve the problem.

Within recent years, the development and use of tungsten carbide as an abrasive-resistant material has been on its way to becoming common practice, and new uses for this material are continually being found. Under most conditions, tungsten carbide, as compared to ordinary steel, will provide adequate abrasion resistance. It must be noted that tungsten carbide is not a material that can be worked and handled like steel. The substance is extremely wear-resistant, but, compared to steel, is quite fragile or brittle. A development program is now under way to achieve a tungsten carbide that will give adequate wear resistance and, at the same time, be resilient enough to keep it from shattering in use.

There are two ways in which this material is presently used in equipment fabrication. The first is to start with a steel part and to coat it by welding techniques with a hard tungsten carbide surface. This results in a part consisting of approximately 50 to 60% tungsten carbide. The second method requires the pressing and sintering of the carbide into a matrix material. With this method, it has been found possible to increase the tungsten carbide content up to about 97%. While this sintering technique was originally developed for the manufacture of machine cutting tools, it is now being extended to parts for particle size reduction equipment.

The pressing and sintering technique requires the use of a matrix material. Generally, cobalt has been used, since it shows the greatest affin-

continued on page 120

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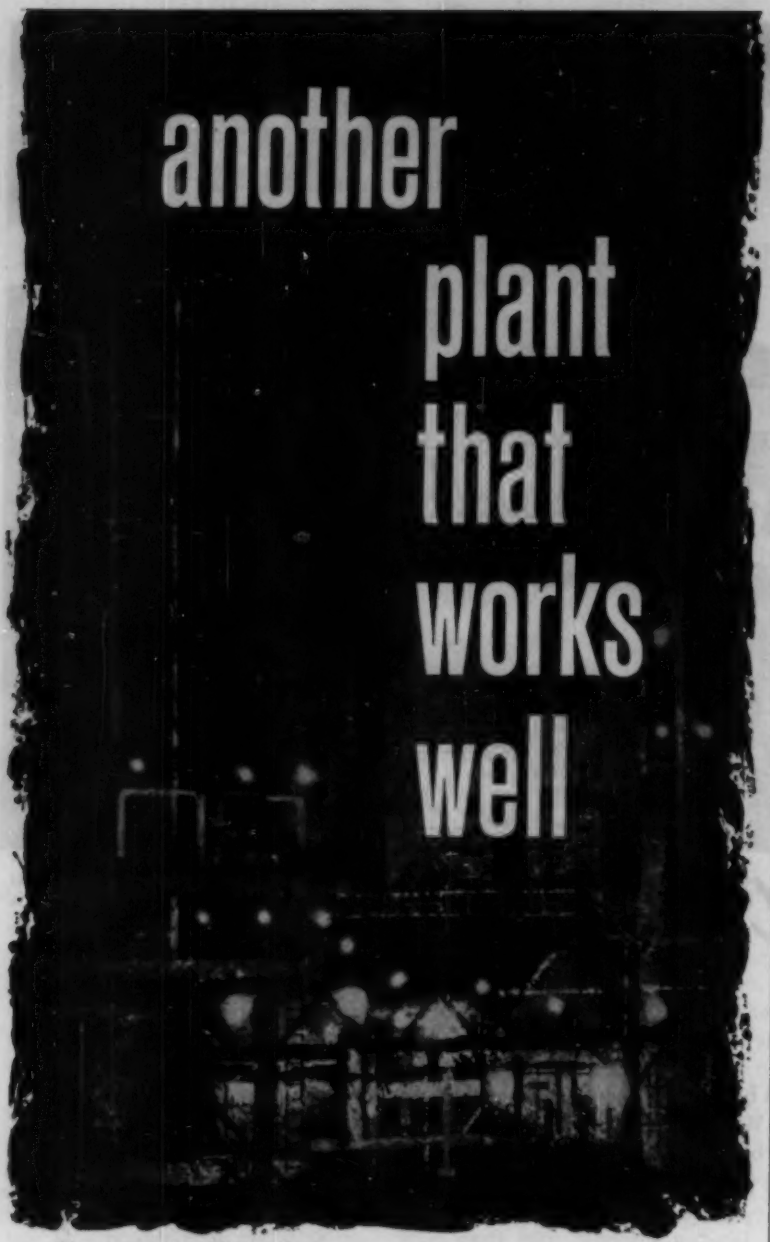

The reason is still simple. Sound engineering, right from the start. Early joint efforts between company researchers and contracting engineers meant both quick start-up and a trouble-free plant design that has not and will not become dated.

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Grinding Equipment

from page 118

ity for combining with the tungsten carbide to form a dense, homogeneous matrix. In some processes, however, the cobalt is attacked chemically by the material being processed, and it has become necessary to use other matrix materials. Recent developments, worked out by the carbide manufacturers, have led to the use of other corrosion-resistant elements such as titanium, chromium, or stainless steel as the matrix material.

The application of tungsten carbide as a welding overlay is an operation which depends primarily on the development of advanced welding techniques. Generally speaking, application is done with an oxy-acetylene torch; particular attention must be placed on proper pre-heating and cooling systems, to obviate warping of the part being coated. Fabricators are urged to work with the manufacturer of the welding rods being used, to work out the proper technique within an individual plant.

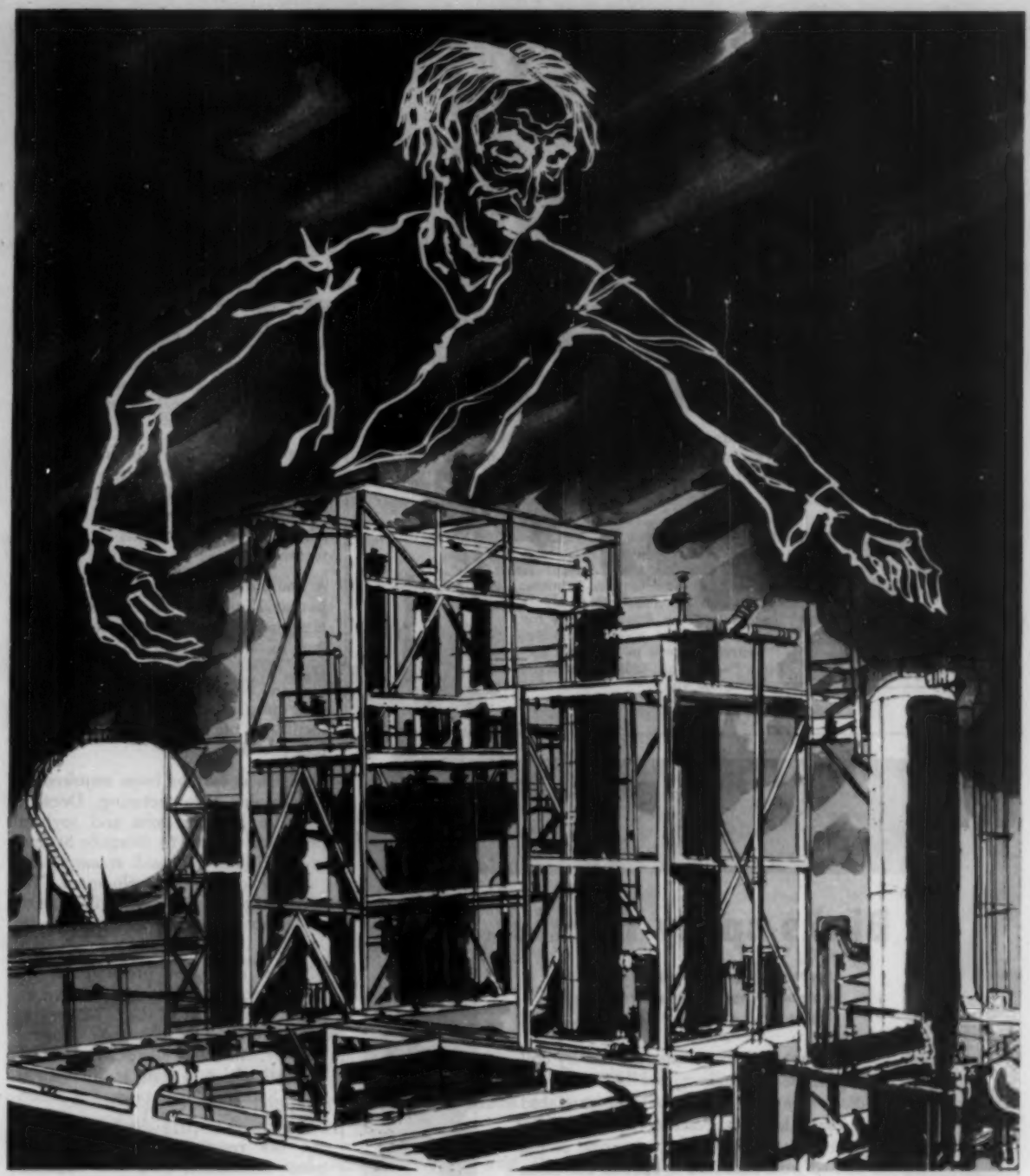
To be presented in its entirety at the coming A.I.Ch.E. National Meeting in St. Paul, Minn., Sept. 27-30; 1959.

A projected multi-million dollar melamine plant marks the entry of Reichhold Chemicals into the expanding market for this product. Initial capacity of the plant, scheduled to go on-stream early in 1961, will be 20 million pounds a year, but designs are for eventual expansion to 50 million pounds. Location, as yet undetermined, will be in the South.

Also planning an expansion program to increase the supply of melamine is American Cyanamid. A facility to be built at Wallingford, Connecticut, according to the company, has an initial capacity of 10 million pounds, will utilize an improved process. It is expected to go into operation by early 1960.

Polyethylene film will be manufactured at a Findlay, Ohio plant purchased by Dow. When conversion of the now vacant 27-acre site is complete, it is expected to serve film customers in the midwest and east.

A company to produce synthetic resins in Caracas, Venezuela, has been formed by a group of Venezuelan industrialists along with Reichhold Chemicals. The new firm will manufacture resins under formulas and techniques developed by RCI, with principle consumers being the surface coating, adhesive, polyester and plastics industries of Venezuela.



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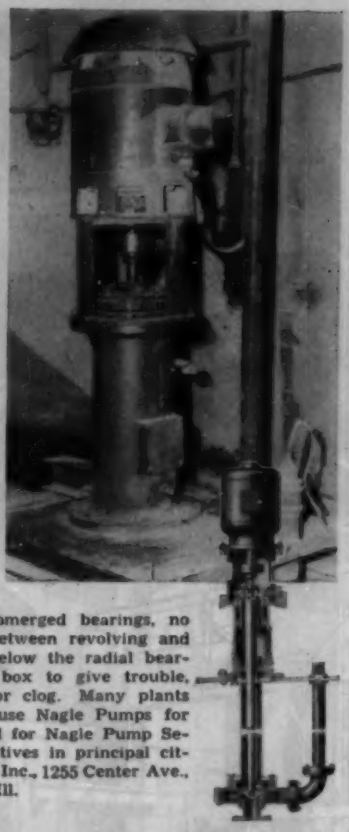

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industrial news

Polycarbonate plastic resins manufacturing gets underway commercially when Mobay's new Martinsville, West Va., plant goes on-stream early next year. The polycarbonate resin will be marketed under the tradename, Merlon. Details of plant capacity have not yet been worked out.

A company to design, fabricate and erect saline water conversion plants, Weir-Chicago Bridge, has been formed with offices in New York City. Joint owners are Chicago Bridge & Iron, and G. & J. Weir, Glasgow, Scotland. Both are builders of evaporating plants.

Expansion of Silica production facilities at Monsanto's Everett, Mass. plant has been completed. The silica plant produces silica, aerogels (Santocels), and collodial dispersions of silica in water (Sytons).

A boost in high purity hydrogen output at Kingsport plant of Tennessee Eastman takes place when new hydrogen installation goes on stream next year. The steam hydrocarbon process will be used, with resulting 99 percent pure hydrogen. Capacity of the facility is planned for 900,000 cubic feet per day.

UBS Chemical has been acquired by A.E. Staley Manufacturing, Decatur, Ill. The Decatur corn and soybean processor expects to diversify Staley's product lines and aid research and polymer chemical development. The Cambridge, Mass., firm will operate as an autonomous unit of the Staley Co.

Styrene monomer production goes ahead in Australia with the formation of a company for that purpose by Monsanto, and Petroleum & Chemical, Sydney, Australia. Construction starts immediately on a plant at Silverwater, near Sydney. Operations are scheduled to begin in 1961.

An ore roasting and sulfuric acid plant installation on a new Canadian plant site at Port Maitland, Ontario, is to be built for Sherbrooke Metallurgical Co. (Matthiessen & Hegeler Zinc). Believed the first commercial installation in Canada of a newly developed type of fluidized roaster, the ore roasting plant will utilize Canadian zinc ores. The contact sulfuric acid plant will use both the gases from ore roasting and from burning elemental sulfur. Engineering and construction contract went to Leonard Construction.

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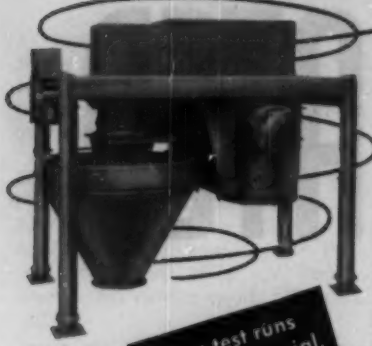

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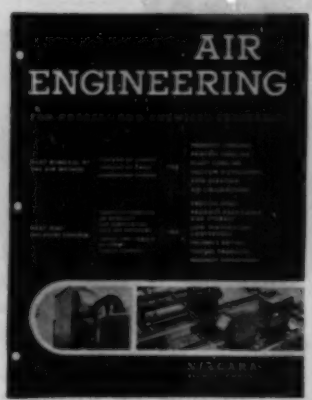

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future meetings

1959—MEETINGS—A.I.Ch.E.

• Austin Tex. Sept. 9-11, 1959. Univ. of Texas **Mid-West Conf. on Fluid & Solid Mechanics.** Co-sponsored by U. of Tex., A.I.Ch.E. & others. Tech. Chmn.: M. J. Thompson, U. of Tex.

• Los Angeles, Cal. Sept. 17-18 1959. Hotel Statler Hilton. **Seventh Ann. Engineering Management Conf. Co-sponsored** by ASME, A.I.Ch.E., AIEE, AIME, ASCE & IRE. For info: L. S. Dennegar, Dir. P. R. ASME. 29 West 39 St., New York 18, N. Y.

St. Paul Minn., Sept. 27-30, 1959. Hotel St. Paul. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: A. J. Madden, Jr., Univ. of Minn. see p. 133

• Portland, Ore. Sept. 10-12, 1959. Multnomah Hotel. **Wood Ind. Conf.** Sponsored by ASME, FPRS & Wash.-Ore. Sect. A.I.Ch.E.

• New York, N. Y. Oct. 27, 1959. Hotel New Yorker. **Annual All-Day Symposium, New York Section, A.I.Ch.E.** Customer-Contractor Relations (Panel): Computer Control Through Process Dynamics; New Separation Techniques.

• Galveston, Texas, Oct. 30, 1959. Moody Convention Center. **14th Ann. Technical Meeting. South Texas Section. A.I.Ch.E.** Prog. Chmn.: R. D. Hornbeck, Alcoa, Rockdale, Tex.

• San Francisco, Calif., December 6-9, 1959. Sheraton Palace. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Engr., Princeton U., Princeton, N. J. **Operations Research**—R. R. Hughes, Shell Dev. Co., Emeryville 8, Cal. **Progress and Problems in Jet and Rocket Combustion**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Thermal Recovery of Petroleum**—P. H. Poettman, Ohio Oil Co., Littleton, Colo. **Fundamental Aspects of Chemical Engineering in the Pulp and Paper Industry**—J. L. McCarthy, Dept. Chem. Eng., U. of Washington, Seattle, Wash. **Turbulence and Turbulent Mixing**—T. Baron, Shell Devel. Co., Emeryville, Cal. **Electro-Chemical Engineering**—C. W. Tobias, Dept. Chem. Eng. U. of Cal. Berkeley, Cal. **Outlook for National Resources**—C. Meyer, U. of Calif., Berkeley, Calif. **Quality Criteria for Catalytic Cracking Stocks & Methods of Preparation**—W. W. Kraft, Lummus Co., 385 Madison Ave., N. Y. 17, N. Y. **Fundamental Concepts of Miscible Fluid Displacement**—P. H. Poettman, Ohio Oil Co., Littleton, Colo. **The Automatic Computer as a Teaching Tool**—W. F. Stevens, Ch.E. Dept., Northwestern Univ., Evanston, Ill. **Selected Heat Transfer Papers**—J. G. Knudsen, Ch.E. Dept., Oregon State Coll., Corvallis, Ore. **Heavy Water Production Processes**—W. P. Bebbington, Dupont, Aiken, S. Car. **Special Lecture Series: Process Development by Statistical Methods** (all day Sunday, Dec. 6)—G. E. P. Box & J. S. Hunter, Statistical Rsch. Group, Princeton U., Princeton, N. J. **Student Program**—D. M. Mason, Stanford U., Calif. **Selected Papers**—M. Manders, Union Oil Co., Rodeo, Calif.

1959—Non-A.I.Ch.E.

• New London, New Hampton, Meriden, (all) N. H. 12 weeks; June 15-Sept. 4, 1959. **Gordon Research Conferences** on fundamentals of engineering and science. Ref. to: W. Gorge Parks, Conf. Dir., U. of Rhode Island, Kingston, R. I.

• Houston, Texas, Sept. 24-25, 1959. Shamrock Hilton Hotel. 3rd. Ann. Tech. Conf. Chemical Div., Amer. Soc. Quality Control.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga. Feb. 21-24, 1960. Hotel Biltmore. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: F. Bellinger, Georgia Tech., 225 North Avenue N.W., Atlanta 13, Ga. **Kinetics**—C. D. Holland, Chem. Eng. Dept., Texas A&M. College Sta., Texas. **Pesticides**—(2 sessions) D. J. Porter, Diamond Alkali, Box 348, Painesville, Ohio. **Nuclear Feed Materials Processing**—D. S. Arnold, American Potash & Chem. Co., Henderson, Nev. **Petroleum, Turpentine, and Solvents**—C. A. Burdell, Southern Wood Preserving Co., East Point, Ga. **Rubber and Plastics Applied to Textile Fibers**—John Warner, Chem. Div., Goodyear Tire & Rubber, 1485 E. Archwood Ave., Akron 16, O. **Bioengineering-Radioisotopes**—W. B. Harrison, Georgia Tech., Atlanta 13, Ga. **Rockets and**

continued on page 126

News from
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Mr. Hollen has been with National Carbon Company since 1955 when he graduated from Fenn College with a B.S. Degree in Chemical Engineering.

He has worked on the development and design of chemical process equipment, and worked directly with users on the installation of carbon, graphite and "Karbate" impervious graphite equipment. Recently, he has been named field sales engineer covering the mid-continent states. His headquarters are in St. Louis.

NEW CATALOG AVAILABLE ON IMMERSION TYPE HEAT EXCHANGERS

A new 12-page catalog on immersion type heat exchangers and circulating steam jets is available from National Carbon Company. It contains complete information on application, installation and operation of standard plate, bayonet, and coil type exchangers, plus circulation steam jets. Write for CATALOG NUMBER S-6620.

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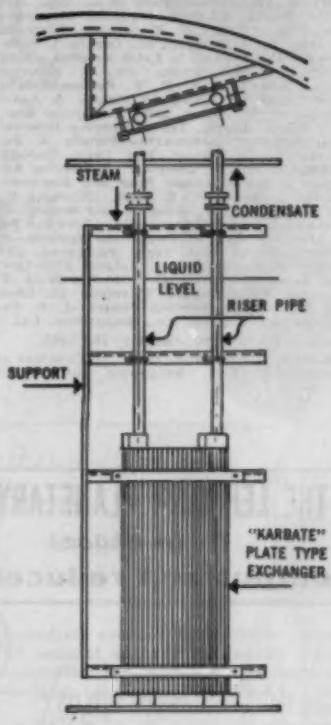
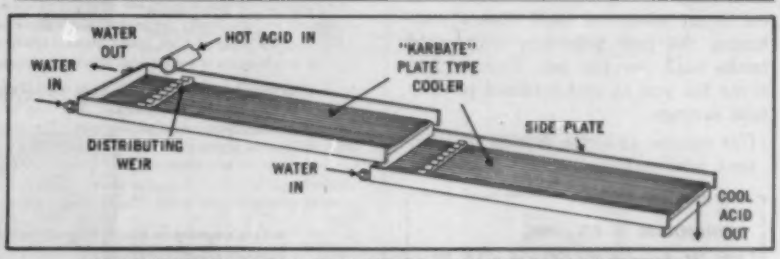
UNIQUE INSTALLATIONS SHOW ADAPTABILITY OF "KARBATE" PLATE EXCHANGERS



"KARBATE" PLATE HEATERS USED IN STARCH MODIFYING PROCESS

In 1956, nine 94" long "Karbate" impervious graphite plate heaters, style VVFS-2, were installed in a starch modifying tank. The complete corrosion resistance and rugged construction of this type of exchanger were factors for its selection in this application. Steam is used as the heating medium.

On the basis of this installation, four additional starch modifying tanks were equipped with "Karbate" plate type units in 1957.



"KARBATE" PLATE EXCHANGERS USED AS TROUGH COOLER

"Karbate" plate exchangers, style VVUS-2, are used to cool 85 to 106% phosphoric acid produced by the thermal process. The standard plate type exchanger is fitted with "Karbate" impervious graphite side, end and drip plates to form a trough. Troughs are installed at a slight incline permitting the acid to flow down the fins. The number of plates in series and/or parallel depends on the cooling required. Some installations are handling acids having inlet temperatures of 400° to 450°F.

For more information, turn to Data Service card, circle No. 111

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For more information, circle No. 23

future meetings

from page 124

Missiles—R. B. Filbert, Jr., Battelle Mem. Inst., 505 King Ave., Columbus, O. **Engineering Education**—H. V. Grubb, Georgia Tech., Atlanta 13, Ga. **Mineral Engineering**—W. A. Koehler, West Virginia U., Morgantown, W. Va. **Fundamentals; Selling: By and To Small Plants**—J. T. Costigan, Sharples Corp., 501 5th Ave., New York 17, N. Y. **Filtration through Porous Media**—F. M. Tiller, Dean Coll. of Eng., U. of Houston, Houston 4, Tex. **Sterilization of Air & Food**—W. B. Harrison, Ga. Tech. **Air Pollution**—A. J. Teller, Univ. Florida, Gainesville, Fla. **High Pressure & High Temperature**—H. R. Batchelder, Battelle Memorial Inst., Columbus 1, O. **Mass Transfer Applications in Waste Treatment**—W. W. Eckenfelder, Manhattan College, Riverdale, N. Y. 17, N. Y. **Student Program**—H. C. Lewis, Georgia Tech., Atlanta 13, Ga.

Deadline for papers: Sept. 21, 1959.

• **Mexico City, Mexico, June 19-22, 1960. Hotel Del Prado. A.I.Ch.E. National Meeting**—Tech. Prog. Chmn.: O. E. Montes, Northern Nat. Gas Co., 2223 Dodge St., Omaha 1, Nebr. **Chemical Engineering in Latin America**—John Mayurnik, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Petroleum and Natural Gas Processing in Mexico & Latin America**—F. W. Jessen, Dept. Petroleum Eng., U. of Texas, Austin, Tex. **Financing International Projects; Optimization-Pitfalls & Potentials**—W. M. Carlson, Eng. Dept., Dupont, Wilmington 98, Del. **Chemical Engineering Education in the Americas; Food and Biochemicals**—E. L. Gaden, Ch.E. Dept., Columbia U., New York 27, N. Y. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Berwyn, Pa. **Transfer Processes in Two-Phase Systems**—S. G. Bankoff, Cal. Inst. Tech., Pasadena, Cal. **Distillation Equipment**—R. Katzen, 3735 Dorwood Lane, Cincinnati, O. **Pilot Plants**—J. T. Cumming, Penn College, Cleveland 15, Ohio. **Cost Estimation; Selected Papers**—J. A. Samaniego, Shell Devel. Co., Emeryville, Cal.

Deadline for papers: January 19, 1960.

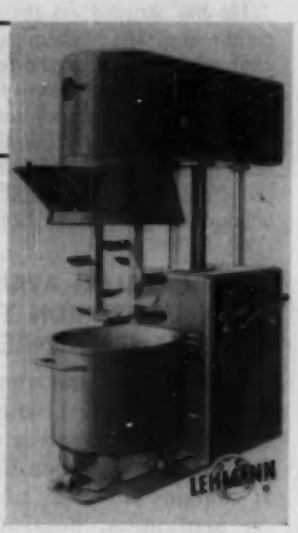
• **Moscow, USSR, June, 1960. 1st Congress of International Fed., Automatic Control. To** cover areas of **Theory, Hardware & Applications of Automatic Control. U.S. participation** sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

• **Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: E. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla. **Transport Processes in Petroleum Recovery; Natural Gas & Natural Gas Liquids**—R. L. Huntington, U. of Oklahoma, Norman, Okla. **Advances in Refinery Technology**—W. C. Offutt, Gulf R&D Co., P.O. Drawer 2038, Pittsburgh 30, Pa. **Petrochemicals**—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hays, Phillips Chem. Co., Bartlesville, Okla. **Piloting, or Why Buy the Restaurant When All You Need is a Meal**—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. **Corrosion & Materials of Construction**—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Worley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. **Statistics and Numerical Methods Applied to Engineering**—R. L. Heiny, 2709 Jefferson, Midland, Mich. **Air & Ammonia Plant Safety**—L. T. Wright, Standard Oil (Ind.) Whiting, Indiana. **Refinery & Natural Gasoline Plant Safety; Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M, Coll. Sta., Tex. **Area Industries. Chemical Reactions induced or Modified by Radiation**—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. **Conservation & Utilization of Water**—P. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Foams**—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program. Selected Papers.**

Deadline for papers: May 2, 1960.

continued on page 128

THE LEHMANN PLANETARY MIXER
improves
output and reduces cost



No engineering detail has been overlooked to make this modern Mixing and Kneading Machine the most efficient and economical in its field. For the intensive and uniform mixing of highly fluid, viscous and pasty materials it is unsurpassed.

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Swivel, tilting, run-out or stationary tanks are provided in capacities from 1 to 350 gallons. The use of several tanks permits almost continuous production. The machine is available in several types and power specifications. Stainless steel or other metals are obtainable if required. The unit can be cleaned quickly when frequent changes are desired in shade or type of product processed. Maintenance costs are unusually low.

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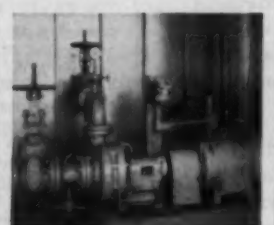
THEY OFFER the type of quality construction that measures up to any standard. Continual checking at every stage of manufacture guarantees the buyer performance he can count on in the field. *The best!*



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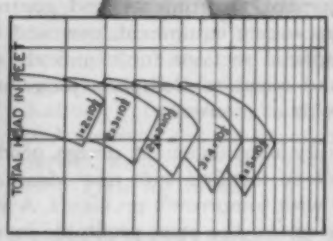

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For more information, turn to Data Service card, circle No. 48

future meetings

from page 126

• Washington, D. C., Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va.
Tentative Program framework: **Chemical Engineering in Govt. Programs.** Agency Oriented: **Nuclear Energy, Health and Education; Agriculture; Foreign Assistance Programs; Resource Development; Utilization and Reclamation; Naval Warfare Technology; Land Warfare Technology; Chemical Warfare, and Basic Research.** Subject Oriented: **Doing Business with the Government; Fluid Particles and Aerosols; Combustion; Materials Deterioration; New Process Techniques; Unsteady State Instrumentation; Computer Control of Processing Units; Missiles and Rockets; Design. Techniques for Very Large Systems Information and Communication; Characteristics of Portable and Expendable Plants and Equipments.**

Deadline for papers: July 5, 1960.

• New Orleans, La. Feb. 26-Mar 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: H. L Malakoff, Petroleum Chem. P.O. Box 6, New Orleans 6, La. **Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry on Gulf Coast; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction; Evaluation of Research & Development Projects; Flow Through Porous Media.**

Deadline for papers: Sept. 5, 1960.

• Cleveland, O., May 7-10, 1961. Sheraton-Cleveland. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 10, O.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Nuclear Chemical Plant Safety—C. E. Dryden, Ohio State U., Columbus, O.

Nuclear Reactor Operations—R. L. Cummings, Atomics International, P.O. Box 309, Canoga Park, Cal.

Drying—R. E. Peck, Ill. Inst. of Tech. 330 So. Federal, Chicago, Ill.

Author Information

Procedure in submitting papers.

1. Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2. Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

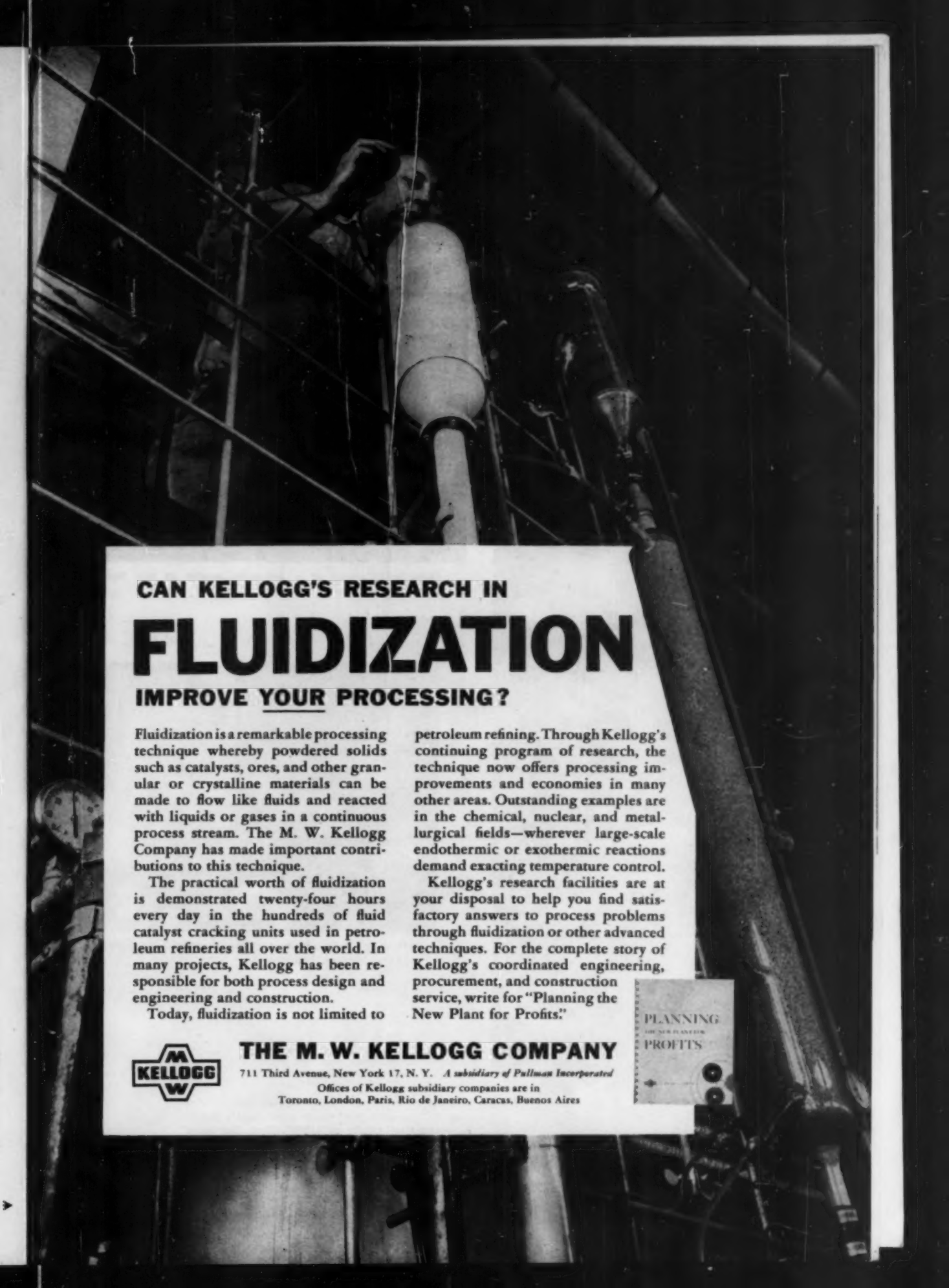
3. Send another copy to Norman Morash, Titanium Div., Natl. Lead Co., So. Amboy, N. J. (Ass't. Chmn. Program Comm.)

4. Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York, 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5. If desired to present paper in a selected symposium send fourth copy to chairman of the symposium.

6. Prepare six copies of manuscript. Send all six to Symposium chairman or the Selected Papers chairman, whichever is appropriate.

For more information, circle No. 70



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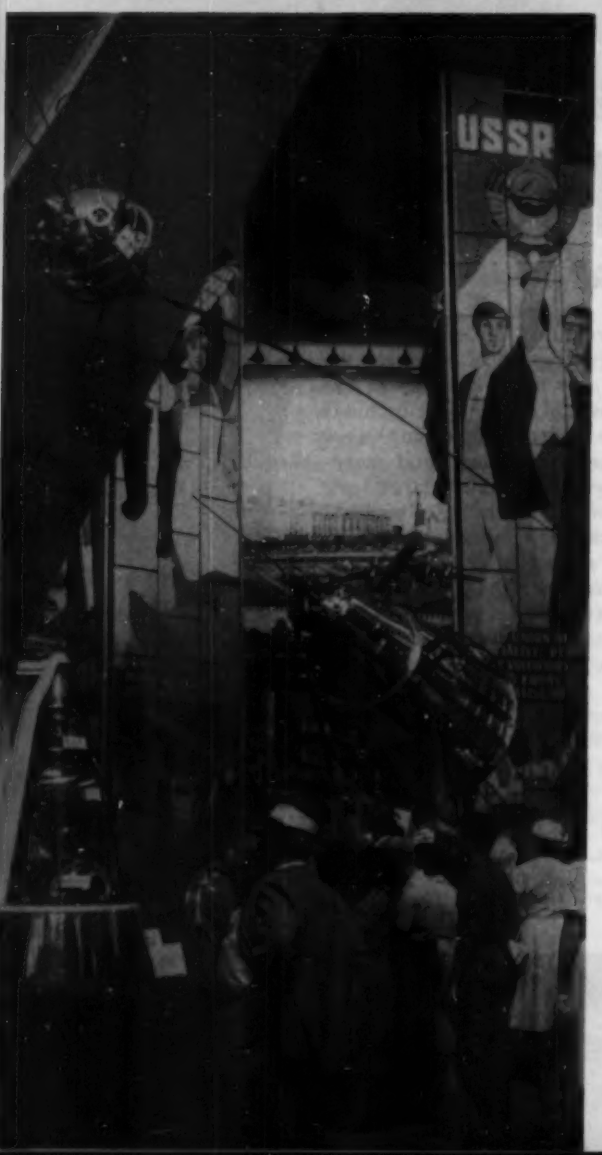
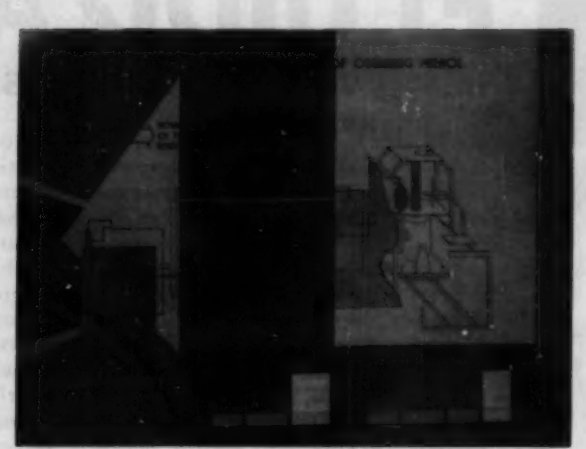
Off-shore oil rig shows modern techniques. Derrick at left drills two wells at the same time.

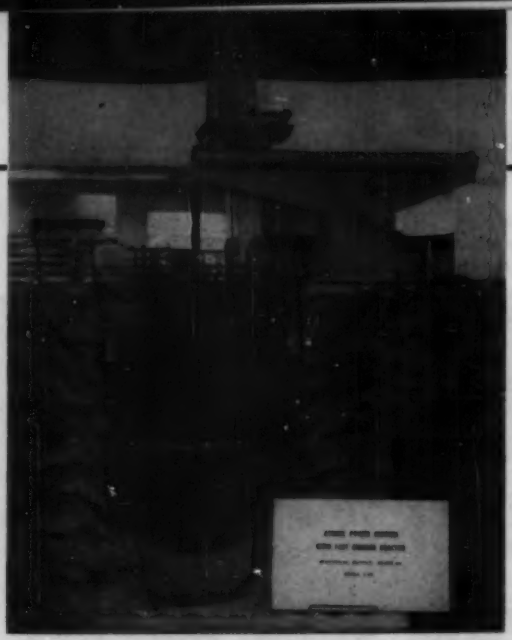
Detailed close-up of a full-scale model of the Soviet's famous dog-carrying Sputnik.





One of the many illustrated panels showing Soviet chemical and nuclear technology.

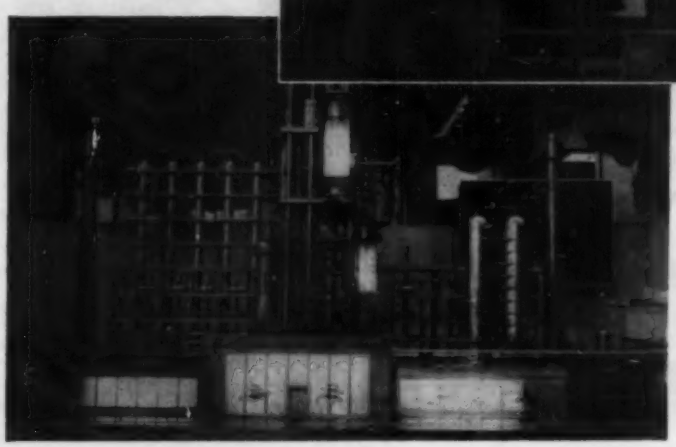
Interested Americans study Soviet Sputnik display in front of one of many giant panels extolling industrial might of USSR. Top: the solar satellite. Below left: dog-carrying chamber in Sputnik, center.



One of many models at the show showing the nuclear technology of the USSR. This one is a fast-breeder reactor.

Soviet Exhibition of Science, Technology, Industry and Culture held in New York's Coliseum

Huge crowds of curious Americans flocked in recent weeks to New York's Coliseum to see for themselves the industrial and scientific accomplishments of the USSR. Here, CEP shows some of the highlights.



Giant butadiene plant model was a major industrial feature of the show. Above, visitors hear a description of the plant seen in full from the feed end. Left, the central unit of the plant complete with colored lights to simulate flow.

St. Paul

23 sessions in four-day schedule

Sept. 27-30th

Two renowned guest speakers will be among the leading attractions at St. Paul (Sept. 27-30). At luncheon on Tuesday, Dr. C. W. Mayo of the famous Mayo Clinic in Rochester, Minn., will speak on *Health, An Instrument for Peace*. The traditional Banquet on Tuesday evening will be addressed by Wernher von Braun, of Redstone Ballistic Missile Base, Huntsville, Alabama. Von Braun's topic has not yet been announced, but his eminence in the field of rockets and missles assures a good talk.

Plant Trips

Monday:

M-1 Archer-Daniels-Midland
M-2 Toni Company
M-3 Minnesota Mining and Manuf.
M-4 Remington Rand Univac

Tuesday:

T-5 Commander-Larabee Milling
T-6 Univ. of Minn.—Chem. Eng.
T-7 Minnesota Mining and Manufacturing
T-8 Great Northern Oil

continued on page 134

Know your authors

Monday Morning

Kitchin Martin Fisher Harmon Bloch Kenny Piret

Zeleny Cadwell Duwell Jebens Johnson Boudart Kevorkian Heath Mason Wright

Monday Afternoon

Dahlstrom Wrotnowski Amundson Penney Trambouze Bondi Simkin Starling Eakin

Ellington McAllister Thodos Lohrenz Swift Kurata

Tuesday Morning

Metzner Lopez-Ramos Tuthill

Weisman Efferding Treybal Rushton Kuhn Soderberg Hitchcock

Tuesday Afternoon

Cornell Knapp

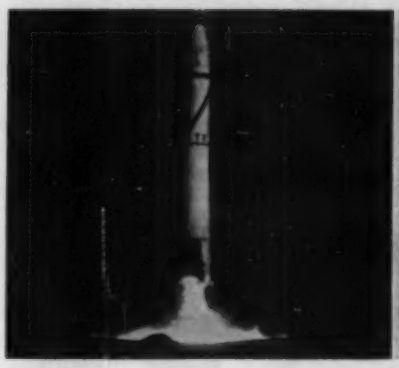
Wednesday Morning

Close Fair Wilke Parker Collins Tucker

Wiley Mason McDonald

PUMPAGE

Goulds news about pumps for process industries



Rocket's red roar

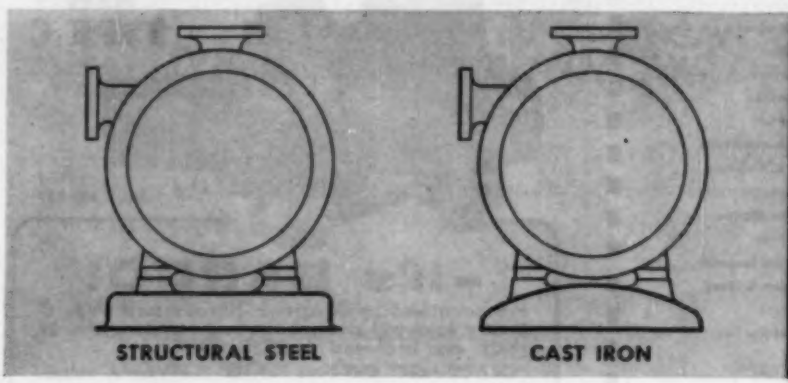
After the countdown—a roaring and soaring! The fuels that make rockets roar contain highly abrasive solids, ignite and burn rapidly with the slightest contact with air or oxygen. Handling them is a problem—pumping temperatures run as high as 550° F. For one government installation, Goulds developed a vertical process pump with an inert gas chamber that is used as a barrier between pumpage and rotating shaft seal. Gas pressure is maintained by an automatic purgerator slightly above suction inlet pressure to insure no contact between the mechanical seal and the abrasive solids. This pump has been found so broadly applicable that it is now a standard model in our line.

Now . . . a centripetal pump!

A unique use of centripetal action lets Goulds Fig. 2520 handle liquid, air, or liquid *and* air! The centrifugal force of the impeller separates the liquid from the lighter air, which accumulates at the center of the impeller and casing. The liquid, circulating at the casing periphery, is directed (by centripetal action) toward the center, pushing the air ahead of it and through the discharge. Once primed, this pump *stays* primed! It can't air bind—even with loops or leaks in your suction line. Handles foaming solutions and emulsions easily. You can use it for almost anything: as a scavenger, for transfer work, for cleaning up, for pilot plant work. Ask for Bulletin 725.6 for all the details!

Latex: Handle with Care

Before synthetic latex can become the bouncy consumer products you see here, it must be a fairly instable liquid, able to gel or coagulate easily. For that reason, a pump must handle latex gently or the impeller will clog and have to be cleaned frequently. Such a pump is the Goulds Fig. 3715—six of which are presently being used by a rubber manufacturer to transfer latex from storage tanks to tank cars and in the latex concentrator line. A semi-open impeller allows a minimum of mechanical shock or friction at optimum efficiency. Normal cleaning operations are performed easily, because the casing cover and impeller can be easily removed without disturbing pipe connections. Bulletin 725.4.



Cast-iron bedplates

A rigid well-grouted bedplate under your pump and driver is the first requirement for trouble-free operation. Accordingly, Goulds furnishes rigid corrosion-resistant cast-iron bedplates as standard at no extra cost. The Goulds special camber top prevents accumulation of corrosive liquids. The camber design with its large accessible grout hole at the high point insures complete fill-up of bedplate cavity with grout. This economical design, jig-drilled for pump and motors, provides integral motor pad, eliminating costly separate motor base.

GOULDS PUMPS

Get all the news monthly — FREE!

If you've liked reading about the new designs and applications of pumps as presented on PUMPAGE, then you'll appreciate getting a sister publication, GOULDS NEWS, mailed to you free every other month. GOULDS NEWS is a 4-page newsletter that highlights new developments in pumps and profitable ways that they are used. You can add your name to our mailing list by merely writing, on your letterhead, to Goulds Pumps, Inc., Dept. CEP-89, Seneca Falls, N. Y.

For more information, turn to Data Service card, circle No. 15

St. Paul Meeting

from page 132

Wednesday Morning *continued*

Wednesday:
W-9 Archer-Daniels-Midland
W-10 Great Northern Oil
W-11 St. Paul Ammonia Products

Ladies Program

Monday the program begins and includes: a tour of the St. Croix Valley; a boat trip on the St. Croix River; luncheon at the famous Lowell Inn; luncheon at the Town and Country Club; the Banquet; and much more.

Braham Lieberman Rosinski Englehart Gruntfest

Shenker Lyman Scala Kirkpatrick Schramm

Wednesday Afternoon

Weaver Lyndall Nelson Vance

Ruud Pigford Romano DeMaria

White Latinen Carberry Bebbington Thayer Teetzel Williamson Abbott Maddox Pelitti

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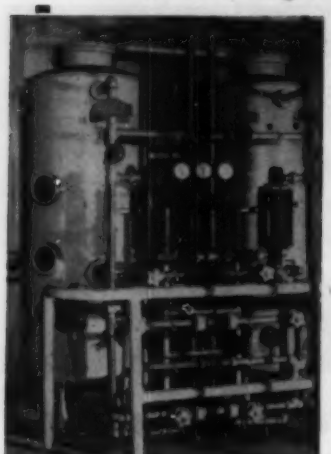
Choose H&T for Water Treating Equipment . . .



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- Baker
- Barrett
- Davison
- duPont
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- Jacques Wolf
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"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. Minimizes corrosion, friction, wear. Stainless steel spring also standard.

RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.

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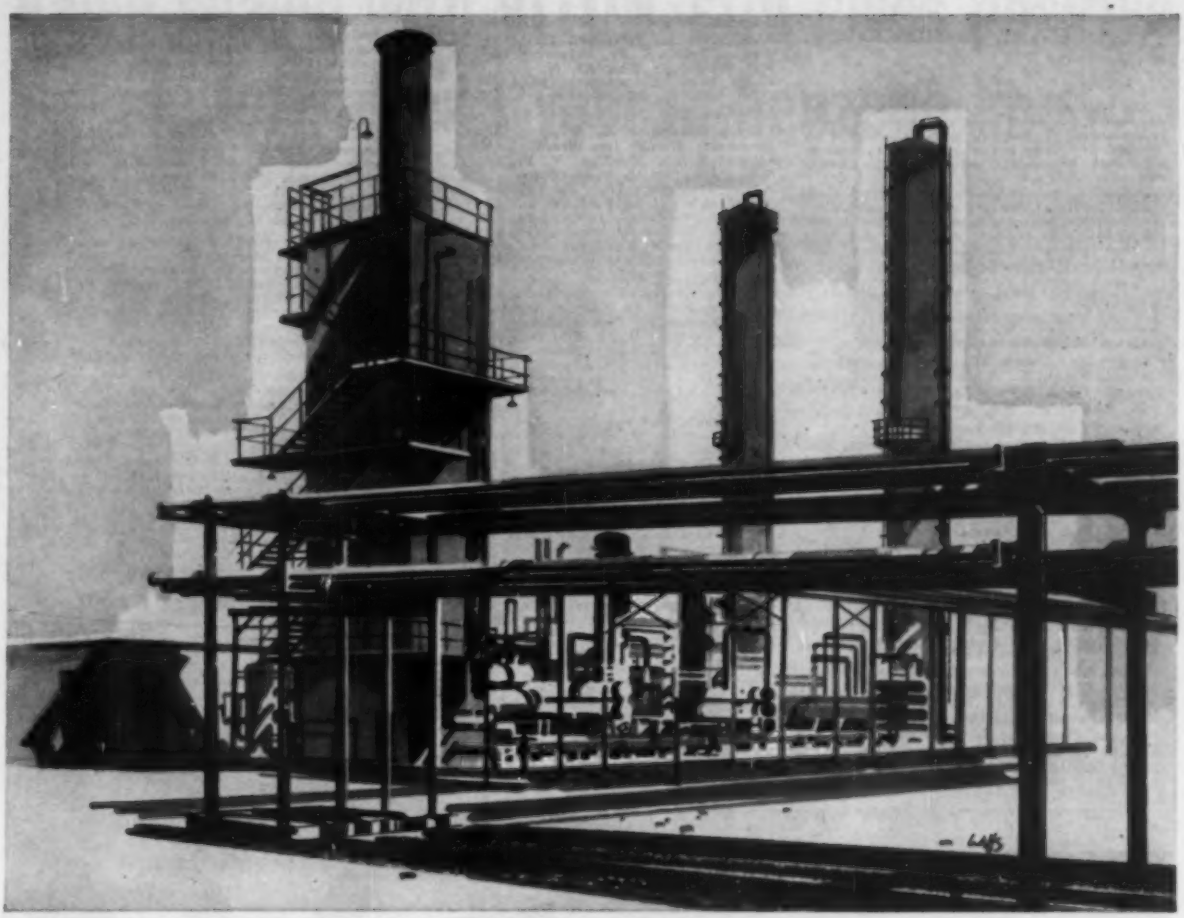

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A.I.Ch.E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before September 15, 1959, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

MEMBERS

Bosworth, Cyrus M., *Syracuse, N. Y.*
Brown, Robert Bruce, *Brevard, N. C.*
Christiansen, Robert M., *Granville, Ohio*
Clauson, Frank A., *Roslyn Heights, N. Y.*
Dobucki, Leonard J., *Frederick, Md.*
Duff, Barrett S., *Whittier, Calif.*
Everson, Carl H., *Elmhurst, Ill.*
Finneran, James A., Jr., *New York, N. Y.*
Gould, Merle L., *Baton Rouge, La.*
Griffin, Harold A., *Copperhill, Tenn.*
Hegarty, Allen G., *Springfield, N. J.*
Hurmence, Howard, *Morristown, N. J.*
Jarratt, Pat, Jr., *Kansas City, Mo.*
Johnson, William Charles, *Kalamazoo, Mich.*
Jones, George Ellis, Jr., *Export, Pa.*
Jones, Thomas L., *Somerville, N. J.*
Kanter, Carl V., *Los Angeles, Calif.*
Knowlton, Dana S., *Plainfield, N. J.*
Lewis, Robert C., *Plainfield, N. J.*
Lilly, Edmund D., *Houston, Texas*
Lindberg, F. H., *Memphis, Tenn.*
Lottes, Henry C., *Miamisburg, Ohio*
Martin, J. Ivan, *Maringouin, La.*
Matthew, Christian J., *San Francisco, Calif.*
Michel, Laurent, *Baytown, Texas*
Paladino, Hugo R., *Melrose Park, Ill.*
Sineath, H. H., *West Chester, Pa.*
Smith, Raymond V., *Texas City, Texas*
Spencer, R. Bruce, Jr., *Pine Bluff, Ark.*
Stedwell, Marion J., *Richland, Wash.*
West, John B., *Stillwater, Okla.*
Whitsel, Travis S., Jr., *Borger, Texas*
Wilt, Daniel S., *Westfield, N. J.*
Woods, John M., *Lafayette, Ind.*

ASSOCIATES

Abrams, Lawrence M., *Brighton, Mass.*
Abramson, Harold Ira, *Brooklyn, N. Y.*
Achlufi, Morris, *Brooklyn, N. Y.*
Acres, Jan Cloe, *Gorman, Texas*
Adcock, Lawrence D., *New Orleans, La.*
Alia, Dominic, *New York, N. Y.*
Anderson, Douglas, *Crystal Lake, Ill.*
Anderson, Lowell B., *Seguin, Texas*
Appleton, David E., *Denver, Colo.*
Ault, Lawrence H., *St. Clair Shores, Mich.*
Baker, Gary L., *Caldwell, Kansas*
Balynsky, George, *New York, N. Y.*
Bambara, Salvatore Eugene, *Brooklyn, N. Y.*
Barco, Samuel U., *Louisville, Ky.*
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Barron, Charles H., Jr. *Seneca, S. C.*
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Berry, Leonard M., *New Gloucester, Maine*
Birenbaum, Herbert A., *Philadelphia, Pa.*
Bissell, Gary D., *Ripley, Tenn.*
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Bonnet, Fred W., *New York, N. Y.*
Borom, W. Robert, *N. Charleston, S. C.*
Bradshaw, Eugene B., *Dakota City, Neb.*
Breitweiser, Gary, *Alton, Ill.*
Breland, Norman L., *Picayune, Miss.*
Brennan, Cal, *Niagara Falls, N. Y.*
Brierley, Ronald H., *Hyattsville, Md.*
Brodeske, James E., *Joliet, Ill.*
Brown, Merton Leopold, *New York, N. Y.*
Brown, Richard J., *Schwenksville, Pa.*
Brugger, Harvey B., *New York, N. Y.*
Brumer, Herbert, *Springfield, Mass.*
Buatti, Albert U., *Brooklyn, N. Y.*
Buckman, Robert H., *Memphis, Tenn.*
Buehler, Raymond L., *Springfield, Mo.*
Burton, Donald H., Jr., *Elsmere, N. Y.*
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Campbell, Robert George, *Port Arthur, Texas*
Campbell, Robert H., *Turtle Creek, Pa.*
Cappers, Murray A., Jr., *Milton, Mass.*
Carroll, Dennis M., *Milwaukee, Wisc.*
Castleberry, Billy W., *Nederland, Texas*
Chae, Young C., *Rapid City, S. D.*
Chakich, Philip, *Bessemer, Mich.*
Chauviere, E. C., Jr., *Waco, Texas*
Clevenger, William W., *Kingsport, Tenn.*
Coffey, Bob, *Longview, Texas*
Coffin, Richard J., *Wilmington, Del.*
Corbin, Richard W., *Baton Rouge, La.*
Corcoran, Thomas F., *Evansville, Ind.*
Corlew, Billy W., *St. Louis, Mo.*
Couch, James Philip, *Odessa, N. Y.*
Cox, Harold A., Jr., *Rochester, N. Y.*
Cosine, Chauncey G., III, *New York, N. Y.*
Curley, Jerome K., *Buffalo, N. Y.*
Dahringer, Donald W., *Glen Ridge, N. J.*
Davee, Robert, *Marion, Ill.*
Delaware, William M., *Bangor, Maine*
Delorme, Raymond V., *W. Warwick, R. I.*
Denigan, E. P., Jr., *Pittsburgh, Pa.*
DeSellier, Raymond F., *Springfield, Mass.*
Dodd, Lawrence G., *Bellevue, Wash.*
Douglass, Emory J., *W. Chicago, Ill.*
Duffield, Peter R., *Montreal, P. Q., Can.*
Engle, Edward B., *Bayside, N. Y.*
Eazzetta, Dominick A., *Highland Falls, N. Y.*
Ellenberger, Andrew C. J., *Euclid, Ohio*
Ellis, Robert H., II, *Baytown, Texas*
English, Howard T., Jr., *Camden, N. J.*
Erwin, Terry Waters, *La Porte, Texas*
Eschner, Donald E., *Ridley Park, Pa.*
Eschweiler, J. C., *Milwaukee, Wisc.*
Eubanks, Ray A., Jr, *Groves, Texas*
Faller, James G., *Wilmington, Del.*
Fancher, Robert B., *Oswego, N. Y.*
Fenoglio, John C., *Clinton, Ind.*
Ferentchak, Rudolph, *La Salle, Ill.*
Fiechtner, Terrance Keith, *Java, S. D.*
Fierstein, Aaron R., *Flushing, N. Y.*
Fiffick, Theodore M., *Uniontown, Pa.*
Fiorelli, Arthur C., *Peckville, Pa.*
Fiorentino, Anthony, *Brooklyn, N. Y.*
Fischbein, Robert, *Bronx, N. Y.*
Foushee, Charles L., *Kansas City, Mo.*
Fox, George Lewis, Jr., *San Francisco, Calif.*
Foy, James F., *Port Sulphur, La.*
Frame, Dennis M., *Charlottesville, Va.*
Francis, Eddie E., *Texas City, Texas*
Franklin, John P., *Bronx, N. Y.*
Fried, Alvin, *New York, N. Y.*
Friedman, Paul A., *Denver, Colo.*

continued on page 138

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Engineers, maintenance supervisors and plant superintendents with pumping problems swear by SK Rotary Gear Pumps. In case-after-case SK Pumps, used as original equipment or as replacements, have solved "in-service" difficulties and have given years of maintenance-free service. What these pumps have done for others, they can also do for you.

New Bulletin G-1 gives full details on standard SK Gear Pumps. Write for your copy.

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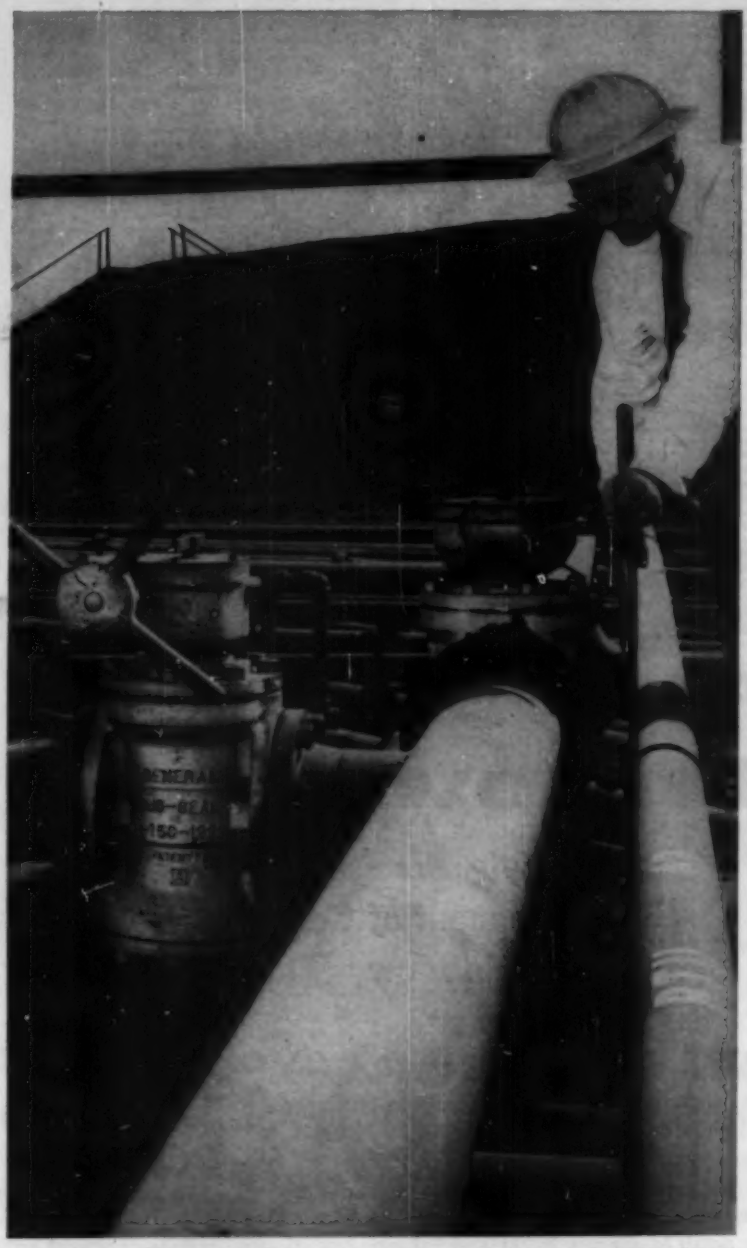
Valve sealed with VITON® still gives positive shutoff after 1 year in benzene line



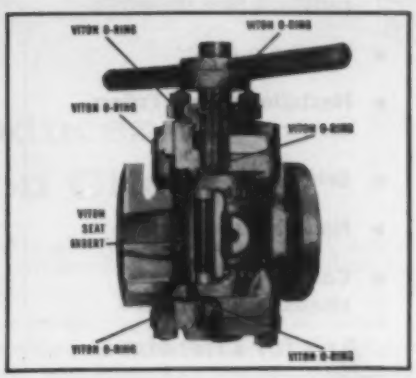
VITON synthetic rubber doesn't swell in the presence of benzene. In these valves at Richfield Oil Company, it has performed well for over a year. Cutaway photo of the valve, right, shows how VITON is used as O-ring and primary seat material.

Here you see a pair of General Duo-Seal Valves in benzene service at Richfield Oil Company's Wilmington, California, Refinery. For more than a year these valves have depended on reliable Du Pont VITON synthetic rubber parts to assure positive shutoff. VITON does not swell in the presence of benzene and other aromatics; it keeps its strength, shape and size—even at elevated temperatures.

Richfield is just one example. Other refineries have successfully used VITON-sealed valves for handling toluene, xylene and blends of these aromatics with other petroleum stocks . . . for 380° F. alkylate gas and for propane at temperatures as high as 400° F.

New Du Pont VITON synthetic rubber offers this kind of resistance to many types of oils, fuels, solvents and corrosive chemicals. Added to this, VITON shows outstanding resistance to high temperatures (450° F. and *up*). It has low compression set, high modulus and good tensile strength . . . plus resistance to ozone, oxygen and weathering.

Such products as gaskets, O-rings, seals, coated fabrics, hose and tubing made from this new synthetic rubber are setting performance records throughout industry. Ask your supplier about the application of VITON parts in your operation. For free booklet describing VITON, write to: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. CEP-8, Wilmington 98, Delaware.



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A.I.Ch.E. candidates

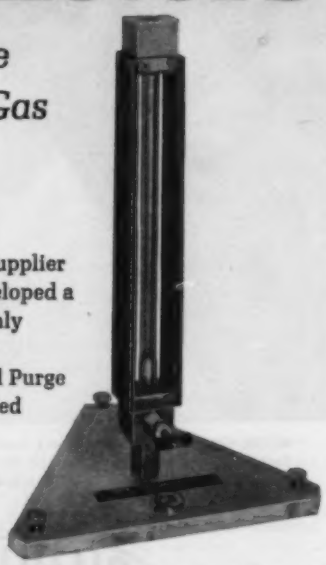
from page 136

Frova, Carl M., *S. Attleboro, Mass.*
Gaffney, James L., *Regina, Sask., Can.*
Gagne, Norman R., *Manchester, N. H.*
Gahan, John R., *Greenville, Miss.*
Gaidon, Peter Raymond, *Merrick, N. Y.*
Gaiser, Charles H., *Bethpage, N. Y.*
Gambrell, James Morris, *Pascagoula, Miss.*
Geise, G. D., *Chester, Pa.*
Gensabella, John C., *Pittsfield, Mass.*
Gerber, Glenn H., *Dillsburg, Pa.*
Gervis, Robert, *Bronx, N. Y.*
Gess, Thomas E., *Kansas City, Kans.*
Giebel, Edmund Arthur, *Brooklyn, N. Y.*
Gilaad, Y., *Montreal, Que., Can.*
Gilbert, Lester James, Jr., *Baldwin, N. Y.*
Gilbert, Stanley, *Irvington, N. J.*
Given, Charles W., *Oak Park, Ill.*
Glicksman, Joel, *Brooklyn, N. Y.*
Gohrband, Roger, *Lake Jackson, Texas*
Goldin, Michael, *Brooklyn, N. Y.*
Gossenberger, Herman F., *Philadelphia, Pa.*
Grebenar, Thomas J., *Bethlehem, Pa.*
Gresham, James C., *Houston, Texas*
Griffin, Robert A., *Anniston, Ala.*
Grossman, Charles, *Newark, N. J.*
Grundy, Doyle, *Corpus Christi, Texas*
Grussecki, Raymond T., *Savoy, Mass.*
Hallen, Carle G., Jr., *Indian Orchard, Mass.*
Hand, Monte J., *Hart, Mich.*
Harris, Donald G., *Connell, Wash.*
Hart, Patrick A., *Charleston, W. Va.*
Harter, Leigh C., *Orono, Maine*
Hartmann, Martin G., Jr., *Brooklyn, N. Y.*
Hartwell, George E., Jr., *Mobile, Ala.*
Hay, Erroll B., III, *Atlanta, Ga.*
Healy, James C., *Cuyahoga Falls, Ohio*
Hebel, Herbert S., *Whitestone, N. Y.*
Heckman, Harold K., *Nazareth, Pa.*
Heller, Steven Lewis, *New York, N. Y.*
Hendricks, Milton H., *Shamokin, Pa.*
Herink, John F., *Rock Springs, Wyo.*
Heron, George H., *Jenkinsville, S. C.*
Herrington, Clair C., *Corvallis, Ore.*
Himes, Frederick Carl, *Charleston, W. Va.*
Hinds, Stephen R., *Kansas City, Kans.*
Holliday, Bernard M., *Natchez, Miss.*
Holtzschneider, Henry O., *Monroeville, Pa.*
Howard, Robert E., *Hamilton, Ohio*
Hunnewell, Keith P., Jr., *Sharon, Mass.*
Ito-Flores, Cruz, *El Paso, Texas*
Ivashkiv, Eugene, *New York, N. Y.*
Jacknow, Joel, *New York, N. Y.*
Jackson, Tom, Jr., *Belzoni, Miss.*
Jarreau, C. L., *Gretna, La.*
Joecks, Albert K., *Haworth, N. J.*
Johnson, Donald E., *Oakland, Calif.*
Johnson, Donald H., *East Cleveland, Ohio*
Johnson, Edlen G., *Republic, Mich.*
Johnston, David L., *Livingston, N. J.*
Jones, Robert H., Jr., *Columbus, Miss.*
Jones, Ronald C., *Albuquerque, N. M.*
Kapo, George, *Mahanoy City, Pa.*
Kass, William, *White Bear Lake, Minn.*
Kats, Donald P., *Amarillo, Texas*
Kennedy, Philip J., *St. Albans, Vt.*
Kimbrow, John R., *Orange, Texas*
Kingsbury, Bob Dee, *Creswell, Ore.*
Kirsanoff, Boris J., *Chicago, Ill.*
Klaben, Arthur S., *Brooklyn, N. Y.*
Knapp, William J., *San Francisco, Calif.*
Knezek, Raymond B., *Olney, Texas*
Knobeloch, John B., *Florence, S. C.*
Kolycheck, Edmond G., *Lorain, Ohio*
Koshes, Charles Frank, *Drayton Plains, Mich.*
Kowal, Donald John, *Beanton, N. J.*
Krafick, Joseph T., *Canonsburg, Pa.*
Krider, Jesse B., *Seattle, Wash.*
Kukura, John F., *Casper, Wyo.*
Kunii, Daizo, *Evanston, Ill.*
Kurta, Melvin H., *Bronx, N. Y.*
Kyle, Benjamin G., *Manhattan, Kan.*
Lai, Kai S., *New York, N. Y.*
Larson, Charles E., *Dearborn, Mich.*
Larson, Ronald Kent, *Holden, Mass.*
Lauber, Jack D., *Yonkers, N. Y.*
Lee, Don E., *Denver, Colo.*
Legan, Robert W., *Richland, Wash.*
Leiser, Roger, *Barberton, Ohio*
Lerdal, Robert H., *Garretson, S. D.*
Lewis, James H., *Jackson, Miss.*
Lieberman, Martin, *Brooklyn, N. Y.*
Ligi, Joseph John, *Scranton, Pa.*
Lindstrom, Duaine, *Raymond, Wash.*
Lipuma, James Anthony, *Newark, N. J.*
Lomax, Douglas T., *Baytown, Texas*
Lorenz, Wayne W., *Lincoln, Neb.*
Lowry, Ivan, Jr., *Folsom, La.*
Luke, David C., *Cincinnati, Ohio*

continued on page 140

New Matheson Flowmeters

for Simple, Precise Measurement of Gas and Liquid Flow



From our experience as a manufacturer/supplier of over 80 compressed gases, we have developed a new line of Flowmeters that provide a highly accurate and reproducible method of flow measurement. The line, ranging from small Purge Meters to laboratory Rotameters is described in detail in our new Flowmeter Bulletin

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The Matheson Company, Inc.

Compressed Gases and Regulators
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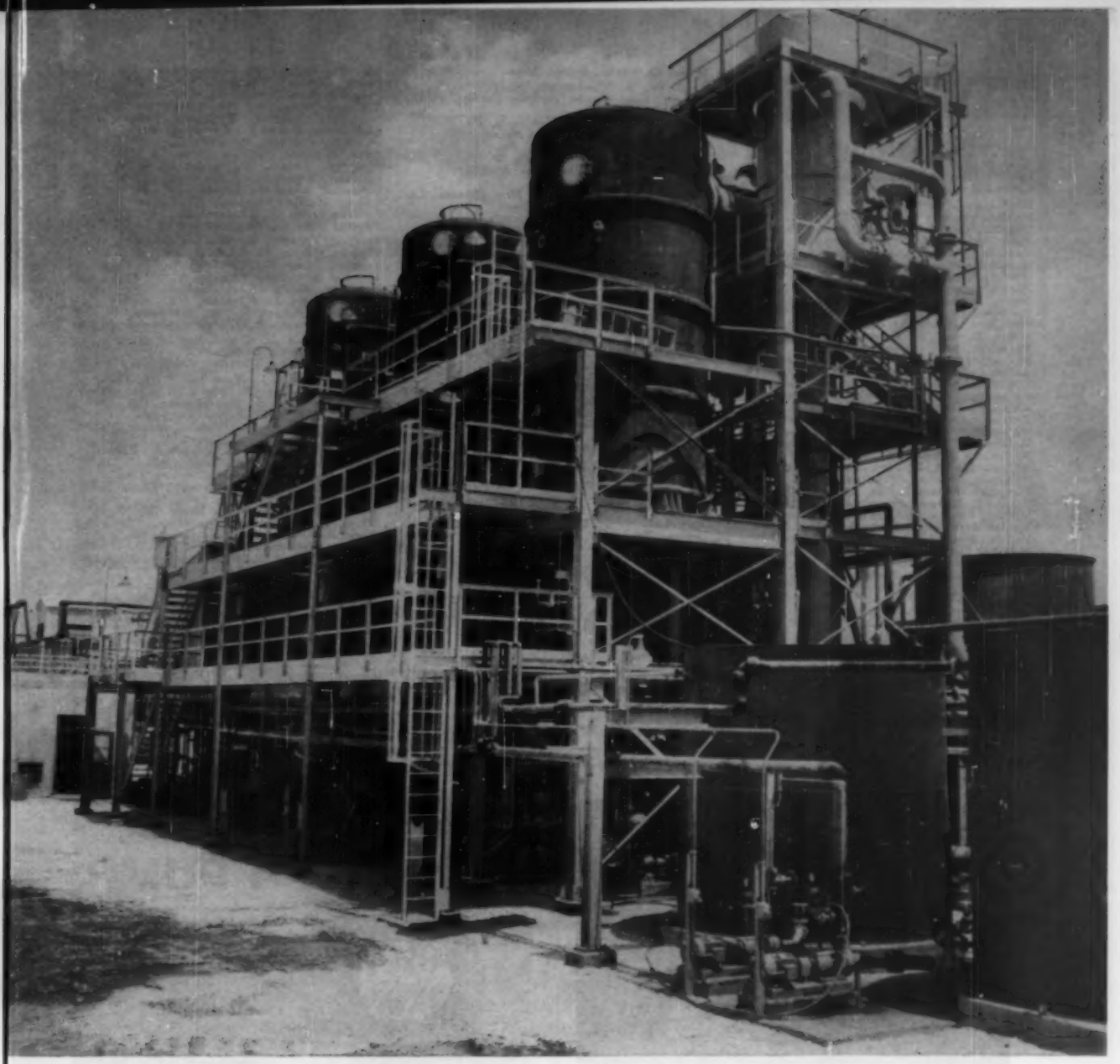

Giant Buflovak evaporator produces 50% and 73% caustic for Jefferson Chemical

At Port Neches, Texas, this 188-ton evaporator for electrolytic cell liquor goes on stream. It's a triple effect operation—concentrating to 50%, recovering the salt, cooling the caustic to remove the salt, and then concentrating as much as half the caustic to 73%.

More caustic is concentrated in Buflovak evaporators than any other kind

Buflovak installations all over the world total 3,000 tons of caustic production per day on a 100% NaOH basis. Units are custom designed and built in single, double, and triple effects, and range in capacity from 10 to 880 tons per day. Buflovak's complete line of evaporators provides cost cutting answers to a wide range of processes.

Bring your own processing problems to Buflovak

A completely equipped Customer Service Lab is at your service to pre-test your product or process. Skilled engineers will study your operation and make recommendations based on test results, or on your own specifications. Write for Catalog 372 on Evaporators, or Catalog 381 on the Customer Service Laboratory.

BLAW-KNOX

BLAW-KNOX COMPANY
Buflovak Equipment Division
1567 Fillmore Avenue, Buffalo 11, New York

For more information, turn to Data Service card, circle No. 103

A. I. Ch. E. candidates

from page 138

Lynch, John A., Jr., *Chattanooga, Tenn.*
Lyncheski, Richard, *Throop, Pa.*
MacDonald, Charles M., III, *Elizabeth, N. J.*
Mahler, Frederic H., *New York, N. Y.*
Maloney, Daniel J., *New Haven, Conn.*
Mann, Amba E., *Parsons, Kan.*
Marsalis, James W., *Cape Girardeau, Mo.*
Marshall, Gordon L., *Amarillo, Texas*
Martin, Robert C., *Anaconda, Mont.*
Martin, Samuel T., *Pompton Lakes, N. J.*
Misra, Baisbhadra, *Azusa, Calif.*
Mathews, Larry Arthur, *Mt. Vernon, Wash.*
Mathiesen, James R., *Astoria, Ore.*
Mayer, Howard R., *Bronx, N. Y.*
McCallum, B. T., *Houston, Texas*
McCartney, John R., *North Tarrytown, N. Y.*
McClary, Terry, *Klamath Falls, Ore.*
McCubbin, Melvin J., *Ridgecrest, Calif.*
McCutchen, Hugh L., *Cedar Mountain, N. C.*
McDevitt, John Paul, *Paulding, Miss.*
McDonald, Allan J., *Bozeman, Mont.*
McDonald, O. B., Jr., *Bethlehem, Pa.*
McDonald, T. J., *Winnipeg, Man., Canada*
McKenney, Ronald A., *Alexandria, Va.*
Mednis, Edmar J., *New York, N. Y.*
Melanson, Joseph, *Arlington, Mass.*
Mernan, William L., *St. Louis, Mo.*
Miner, J. Ronald, *Lawrence, Kan.*
Minton, Paul E., *Charleston, W. Va.*
Mohler, Stanley H., *Savannah, Ga.*
Mohun, Richard Allen, *Temple, Texas*
Mollohan, Bill D., *Charleston, W. Va.*
Molloy, Jack, *Anniston, Ala.*
Moore, Michael A., *Dallas, Texas*
Moore, Robert A., *Salem, Va.*
Mudge, Lyle K., *Selby, S. D.*
Muller, Edward, *Yonkers, N. Y.*
Mulroney, John P., *Philadelphia, Pa.*
Nebeker, Eugene B., *Los Angeles, Calif.*
Nelson, Robert W., *Boston, Mass.*
Nemanic, Donald J., *St. Paul, Minn.*
Nieradtka, Donald J., *Middlesex, N. J.*
Nutter, James L, *Lawrence, Mass.*
O'Connell, Joan P., *Woodside, N. Y.*
O'Connor, Thomas J., *Worcester, Mass.*
O'Neill, Ben Goodwin, *Cronshaw, Miss.*
O'Quinn, Wayne, *Osyka, Miss.*
Pabbi, V. R., *Tonawanda, N. Y.*
Paquin, Jean Claude, *Jacques Cartier, P. Q., Can.*
Pelhoda, William W., *Bethlehem, Pa.*
Peakes, David E., *Bangor, Maine*
Pease, Robert, *Wilmington, Del.*
Penek, Clement C., *Monsanto, Ill.*
Peters, Donald L., *Dearborn, Mich.*
Pierce, Doyle C., *Trion, Ga.*
Planchard, Jerome A., Jr., *New Orleans, La.*
Pongetti, Robert, *Shelby, Miss.*
Poor, Clifford F., *Butte, Mont.*
Prestia, Paul, *Connellsville, Pa.*
Pryor, Harold E., *West Columbia, S. C.*
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Ramsdell, Earl W., *Sebago Lake, Maine*
Range, Walter K., Jr., *Portland, Ore.*
Rausch, Karl W., Jr., *Hamden, Conn.*
Ray, Joel, *Brooklyn, N. Y.*
Reed, Dan A., *Duncan, Okla.*
Reeves, William R., *Louisville, Ky.*
Regan, Thomas J., *Medford, Mass.*
Reiley, Norman John, *Bellaire, Mich.*
Renn, W. Eugene, *Potsdam, N. Y.*
Repetti, Ronald V., *Dayton, Ohio*
Richard, Wayne C., *Charleston, W. Va.*
Richardson, Harold E., *Fort Mill, S. C.*
Riches, Kenyon A., *Laurelton, N. Y.*
Rippel, Rodney, *Baton Rouge, La.*
Roenicke, William L., *Saginaw, Mich.*
Rohr, M. Robert, *Haddonfield, N. J.*
Roseberry, Festus J., Jr. *McComb, Miss.*
Ruppel, Thomas C., *Pittsburgh, Pa.*
Russell, W. Horton, *Weston, Conn.*
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Seyfarth, Huey A., *Natchez, Miss.*
Shaver, Robert G., *West Concord, Mass.*
Sheely, Clyde Q., Jr., *State College, Miss.*
Shelley, J. A., *Austin, Texas*
Shirley, Thomas W., *Sault Ste. Marie, Mich.*
Sikoraki, P. E., *Decatur, Ala.*
Simon, Jay, *Bronx, N. Y.*
Sites, Ernest S., *Charleston, W. Va.*
Slagel, Robert B., *Ironton, Ohio*
Smith, Lee D., Jr., *Irving, Texas*
Smith, Walter R., *Wilmington, Del.*
Snell, John B., *Madison, Wis.*
Solcher, Albert K., *Austin, Tex.*
Soroka, Thomas P., *Wilkes-Barre, Pa.*
Speck, Gerald E., *Americus, Ga.*
Spence, James Donald, *Natchez, Miss.*
Spencer, George W., III, *Milwaukee, Wis.*
St. Clair, James H., II, *Austin, Texas*
Steinmeyer, Daniel E., *Kirkwood, Mo.*
Standish, Franklin, *Indianapolis, Ind.*
Stern, Richard D., *New York, N. Y.*
Strachan, Richard W., *Wollaston, Mass.*
Strickler, James H., *Folly Beach, S. C.*
Striepens, Aloys H., *Brooklyn, N. Y.*
Sulkes, Martin, *Flushing, N. Y.*
Sullivan, John J., *Chicago, Ill.*
Swalm, Dave C., *Baytown, Texas*
Ticknor, Franklin David, *Port Edwards, Wis.*
Tisdale, Marion E., *Whistler, Ala.*
Tenney, Edwin D., *Westfield, N. J.*
Torrisi, Salvatore, *Maplewood, N. J.*
Treglown, E. J., Jr., *Arsenal, Ark.*
Trotter, Peter J., *Honolulu, Ha.*
Truesdell, Leonard C., Jr., *Winnetka, Ill.*
Turnbull, James A., III, *East Orange, N. J.*
Visser, Melvin J., *Grand Rapids, Mich.*
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Voss, Donald L., *Whittier, Calif.*
Walker, William L, *Montreal, P. Q., Can.*
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Warden, Robert B., *Swarthmore, Pa.*
Warner, Vernon E., *Kansas City, Mo.*
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Walter, Thomas E., *Rochester, N. Y.*
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Weamer, George L., *Berkeley, Calif.*
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Wiesenborn, Robert F., *St. Louis, Mo.*
Williams, David J., *Glenshaw, Pa.*
Williams, Ralph G., *Mountain Iron, Minn.*
Winski, Donald T., *Brooklyn, N. Y.*
Witte, Monte D., *Dallas, Texas*
Wolven, Charles L, *St. Anne, Ill.*
Wong, T. K., *Houston, Texas*
Wright, Wilton, *Pine Bluff, Ark.*
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RANDOLPH PUMP

Safely and efficiently handles...

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- STERILE SOLUTIONS
- GASES

Operates on a principle designed to eliminate all contact of moving parts with the material being pumped. A tube is threaded through the pump body where it is subjected to the squeegee action of a double rotor. The result is a smooth flow of liquid or gas through the tube. Ideal for jobs where corrosion, contamination or abrasion is a problem. Two models — 54 and 185 gallons per hour. Available with or without motor; also with speed controls and explosion-proof fittings.

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Fossil vs. nuclear fuel, legal problems, at local sections

The known reserve of natural gas in this country, at the present rate of consumption, would be depleted in twenty years, Don Katz, national A.I.Ch.E. president, told the **Detroit Section** (*Cliff Armstrong*) in June. Present rate of consumption is about 12 trillion cubic feet a year, while known reserves are 250 trillion cubic feet. Therefore, since the possibility exists that the reserves will be depleted, atomic power becomes important. (The heat equivalent from fission of uranium produced in the United States last year is 1.8 times the heating value of all the known reserves of oil, gas, and coal in the country.)

At present to allow peak consumption, excess gas from Texas is kept in exhausted gas wells in Michigan. The gas piped in from Texas is stored underground so that peaks of gas usage during which the consumption exceeds the supply can be taken care of. As it is, last winter 65 million cubic feet were withdrawn from storage in Michigan. On a heat content basis, gas is now the cheapest fuel in Michigan.

Some comparative data on wells being drilled follows:

12,000	220-260F	Gulf Coast
1200	63-65 F	Michigan
4000	120F	Michigan

Pressure vs. depth

12,000 ft.	6000-7000 lb./sq. in.
4000	4000 lb./sq. in.

Use of nuclear power reactors is approximately ten years away in this country, says H. J. Kamack, Du Pont. He addressed the **Maryland Section** (*John W. Holtz*) April meeting. Power demands will then outstrip combustion fuel supplies, making atomic reactors economical. Present commercialization is small, since economic considerations and reactor size restrict the use of atomic reactors to large power stations and vehicles. The expanded program, however, is centered on research and testing to develop reactors for future use.

Continual litigation, ranging from recent local damage suits to union disputes and anti-trust legislation, has had a great impact on the chemical industry with respect to both cost and policy, according to C. W. Tuley, vice president Tennessee Manufacturers' Association. He spoke to the **Nashville Section** (*R. D. Brown*) in April. Litigation often results in legislation, explained Tuley, and operations within the industry have been and will continue to be, greatly affected by this legislation.

Computer control

Computer control is broken down into four steps, J. F. Pink, Southwestern Electronics, told the **East Tennessee Section** (*James E. Williams*). In the first step, the process characteristics are determined so that optimum operation can be reduced to mathematical formulae. Local optimizing controls are then installed to provide optimum operation. Central logging of essential data follows, and the final step is overall control of the plant operation by computer.

Newer mercury type cells produce a high-grade caustic suitable for rayon manufacture, whereas the older diaphragm type cells produce a lower grade caustic which must be purified for rayon use. This was one of the points made in W. C. Gardiner's address on *Development in the Chlor-Alkali Industry* to the **New York Section** (*Reed Garver*), in May. In spite of this, the two cells are still competitive because of high initial cost of installing the mercury cells.

Engineers' status

Engineers do not have the status in Germany that they enjoy in this country, H. Winnicki told the **Charleston Section** (*N. R. Kouba*) in April. German chemists receive a broad training and consequently dominate the chemical industry in that country. In European chemical plants, he said, it is accepted practice to encourage monopolies and price fixing policies. Winnicki, who was in the Geneva office of Food Machinery and Chemical, found from his experience that if one is understanding and appreciative of Europeans and their methods, he will have no trouble getting along in Europe.

continued on page 142

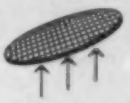
a filter man's thinking

"Expediency: when time is more precious than gold (or platinum)"

BY JULES P. KOVACS, V. P., PUROLATOR PRODUCTS, INC.

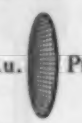
There's more than one way to skin a cat . . . or filter a chemical that fights any attempt to tame it.

As an example, here's a problem we recently licked in developing a diffusion plate bed support for a highly corrosive gaseous fluidized bed reactor, operating at very high temperatures. Pore size had to be 25 microns, able to support 20 psi. And it was needed in a *hurry*.



Now, anyone who knows filters could pick metals for such a job. The obviously ideal medium would be inconel. Trouble was, it was impossible to obtain a fine enough inconel screen. Of the only other metals that could withstand the corrosive action, gold lacked high temperature strength; platinum was too weak without support and too costly, though it did offer the high temperature strength and corrosion resistance needed. And that's where Purolator's special capabilities came into play.

Our engineers solved it by combining the finest mesh size of platinum available—150—with a fused facing of porous gold powder to reduce pore size to the specified 25 microns — and supported by inconel grids. Problem solved. Customer deadline met.



But the story doesn't end there. Purolator engineers immediately set about to find a way to take advantage of standard inconel mesh economy for similar applications. This is how we do it: inconel metallic edge type units are sliced in two, and two of equal thickness are punched out. One is rotated 90° from the other and fused by Purolator's exclusive process. By carefully controlling the amount of fusion material, we produce the exact pore size required. Simple?

It's *not* simple, of course. But it's typical of Purolator's complete service for special jobs. We live with challenges all the time. Want to read about some? Our brochure called "New Roles for Filtration" is just off the press and it will be interesting reading. Send for your copy.

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Rahway, New Jersey and Toronto, Ontario, Canada

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local sections

from page 141

The **Detroit Section** (*Clifford Armstrong*) has been asked for its assistance in the preparation of a pamphlet on the Chemical industry in the Detroit area. The pamphlet will be put out by the Institute for Economic Education, in conjunction with the Detroit School Board as part of a series on the general subject "What Detroit Workers Do".

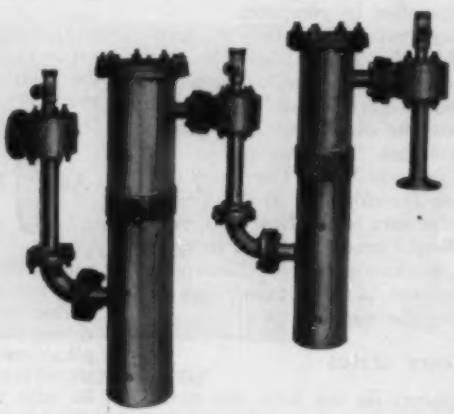
The development of competitive fuel cells within ten years was predicted by Harold R. Schmidt, at a joint meeting of the **Columbia Valley Section** (*B. F. Judson*) and the local ACS section in June. Intense interest, he said, in fuel cells as possible competitors for chemical and solar batteries, and for thermoelectric power units, has been spurred by unique power needs for commercial and space use. Work is underway at GE to develop a new type of energy conversion system, he said. Some of the problems associated with building an ideal cell have led to the development of a Redoxcell in which the hydrogen and oxygen react with intermediate compounds rather than directly. Sub fuel cells, when perfected, would have energy conversion efficiencies as high as 50 to 60 percent.

A jet aircraft which costs $5 million is bought on an engineering drawings and specification basis thus exhibiting the confidence airlines have in their industry engineers, the **Atlanta Section** (*L. M. Wylie*) meeting in June was told by Fred Schwaemmle, Delta Airlines. He talked on engineering aspects and accomplishments of the aviation industry.

Also meeting

A breakthrough in space engine technology is necessary, J. W. Townsend, Jr. told the **National Capital Section** (*Joseph L. Gillman*) in May. Townsend, assistant director, Goddard Space Flight Center, NASA, went on to say he thought we would get the breakthrough...Future trends on utilization of natural gas liquids was discussed at the **Bartlesville Section** (*R. C. Harrison*) April meeting. Speaker was W. N. Hagler, Refining Division, Cities Service Oil . . . D. L. Katz presented various theoretical considerations concerning finned tube heat transfer to the **Central Ohio Section** (*Joseph H. Oxley*), and Roy Corby, Battelle, part of a seven man team that went to Lebanon to aid the Industry Institute of Lebanon told of his experiences during two years in that country . . . The field of clarification and purification was covered at the May **Pittsburgh Section** meeting (*V. N. Hurd*). C. P. Blakeley, Hagan Chemicals & Controls, was guest lecturer . . . H. M. Corley, assistant to vice president for research, Armour & Co., talked to the **Wisconsin Chemical Engineers Society** (*Grant P. Lawless*) in May on market research as applied to product development . . . Effects of radiation on the human system, and responsibilities of professional men in the matter of fear of radiation hazard as a community problem, were discussed by W. D. Claus at the **Chemical Engineers Club of Washington** (*Bill Watkins*) April meeting. Claus is with AEC as special assistant to the director, division of biology and medicine . . . Plant tours taken by several sections within the past months: **Western Massachusetts Section** (*J. F. Flanagan*) saw Shawinigan Resins in May. The firm makes polyvinyl butyral, polyvinyl acetate and alcohol, and copolymers . . . Standard Oil Refinery's new No. 5 pipe still, a 68,000 B/D crude distillation unit, was inspected in June by **Alton-Wood River Section** (*A. W. Frazier*) members . . . Annual plant trip of **New York Section** (*Clem Labine*) took them to American Cyanamid's Bound Brook, N. J. plant . . . **Western New York Section** (*Reed E. Garver*) had a look at the new State Power Authority Project at Niagara Falls in June . . . Architect Carl Koch spoke to the **Boston Section** (*Ralph Wentworth*) in April on design trends in modern living . . . First ladies' night of **Central Illinois Section** (*M. S. Peters*) heard Beth Peterson, Du Pont, on research aspects in development of synthetic fibers . . . Ladies' night meeting at **Bartlesville Section** (*A. J. Andrews*) in May was taken on a tour of Tahiti, when R. W. Thomas, vice president Phillips Petroleum, described his trip there . . . A run-down on new lube oil facilities at Shell's Wood River refinery was given the **Alton-Wood River Section** (*A. W. Frazier*) in March . . . **Fairfield Country Chemical Engineering Society** (*William J. Quinlan*) listened to a lecture on space technology in May. H. Grosch, Military Products Division, IBM, spoke.

a jet for every job



Corrosive fluid handling problem? There's a Jet-Vac ejector that will solve it efficiently and at low-cost.

Like this 3-stage Jet-Vac ejector, for example. Its stainless steel constructon affords better internal and external corrosion resistance, lighter weight.

Jet-Vac ejectors can be made with super alloys, many other special corrosion resistant materials which give a new measure of protection for handling corrosive fluids.

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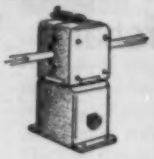
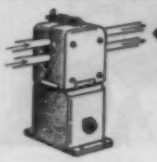
PUMPING IDEAS

POSSIBLE ONLY with a SIGMAMOTOR PUMP

MOVE CORROSIVE LIQUIDS

Material being pumped never comes in contact with pump mechanism. Wave-like motion of steel fingers forces material through Tygon tubing. By changing size of tubing, capacity can be increased or decreased. Pump housing opens for removal and insertion of tubing.



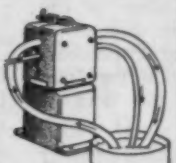


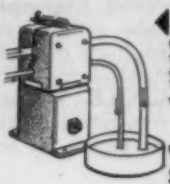
PUMP 2 OR 3 DIFFERENT LIQUIDS SIMULTANEOUSLY

Some models will accommodate up to four tubes so that four different liquids can be passed through the pump at one time without danger of contamination.

FEED AND MIX

One or more tubes can be feeding material to a mix while a larger tube is recirculating the liquid to produce agitation and thorough mixing. Viscous materials can be pumped without danger of gumming or plugging. Remove tube and pump is clean.





METER ADDITIVES

One or more additives can be pumped to a solution in the exact amount desired by selecting the correct size of tubing and regulating pump speed. Various controls can be incorporated to close valves ahead of pump.

Capacities from 0.5 cc. per min. to 4.5 G.P.M.

Write for complete information on sizes and capacities.

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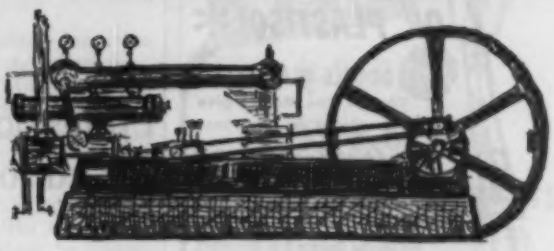
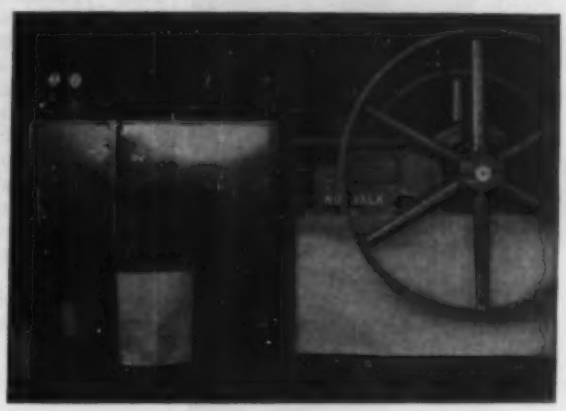
NORWALK COMPRESSORS



This Norwalk compressor, installed in 1908, is in an acetylene manufacturing plant in the midwest, is still in operation.



Factory view of current three-stage acetylene compressor, as manufactured by Norwalk Company.

Every Norwalk compressor is test-run at the factory, then taken down for complete inspection before reassembly and shipment.

Norwalk makes compressors from single stage to six stages, from 125 to 25,000 psi pressure, for gases listed below:

ACETYLENE	HCL
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ETHANE	OXYGEN
ETHYLENE	

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NORWALK COMPANY INC.

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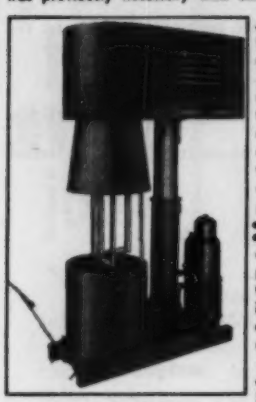
DOUBLE PLANETARY

Change Can Mixers give better mixing in less time!

At *Thiokol* solid propellant plant in Elkton, Md., this Ross #130CDM variable speed 100 gallon Mixer produces the **same high quality mix as obtained in Horizontal Double Arm Kneaders, and in ⅓ the mixing time.**

With no bearings or stuffing boxes in the product zone, stationary can, completely enclosed mix, and remotely controlled raising and lowering device, the Mixers are as safe in operation as they are efficient. Mixers have low original and maintenance cost, are easy to clean, and extremely versatile in operation.

Lower illustration shows an 85 gallon #130-CDM Double Planetary Change Can Mixer furnished a leading concern for mixing plastisols of several types ranging up to 200,000 centipoises. Customer reports Mixer in operation 24 hours/day with mixing time per batch only 15-20 minutes; while the quality of mix and dispersion is so high that the final product is obtained in the Mixer alone — without further processing through a Three Roll Mill as was previously necessary with other Mixers.



Jacketed cans for heating or cooling material during mixing, dolly trucks, gates on cans for discharge, and vacuum tight covers can be provided.

*----or any other heavy paste material. On paints, inks, pharmaceutical products, caulking compounds, and other similar materials, the Ross Double Planetary Change Can Mixers mix and disperse up to 30 times faster than other Mixers.

Mixers available in 1, 2, 3, 4, 6, 8, 12, 20, 25, 65, 85, 125 and 150 gallon sizes. *Write* for complete information on these or other types of Ross mixing, grinding or dispersing equipment!

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people {in management and technology

Professional Progress Award to Marshall

William R. Marshall, Jr. has been named the 1959 recipient of the A.I.Ch.E. Professional Progress Award. Marshall, associate dean of the University of Wisconsin College of Engineering, and associate director of Wisconsin's Engineering Experiment Station, won the citation for "outstanding progress in the field of chemical engineering."

Marshall, who has been on the faculty of the university since 1947, has been in charge of graduate research and coordination of research activities in the field, in addition to his regular teaching duties, and his post with the Experiment Station.

The educator is co-author of a textbook illustrating applications of differential equations to chemical engineering problems, and author of the drying section, *Chemical Engineers' Handbook*. He has also authored or co-authored more than thirty research papers. In 1953, Marshall was presented with the A.I.Ch.E. William Walker Award in recognition of his outstanding technical papers on re-

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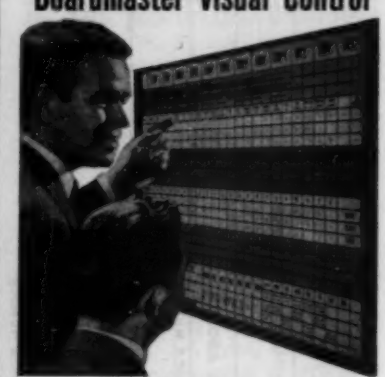

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search in chemical engineering.

Before joining the university faculty, Marshall was at DuPont's Experimental Station in Delaware. Some of his other activities are: chairman advisory panel, engineering sciences division, National Science Foundation; chairman review committee, Chemical Engineering Division, Argonne National Laboratory; and member of the advisory committee for nuclear engineering education, Associated Midwest universities.

The $1000 award and certificate, given by the Council and Awards Committee, A.I.Ch.E., is sponsored by Celanese Corp. Terms of the award call for the recipient to have made a significant contribution to the science of chemical engineering, such as a theoretical discovery, or development of a new principle, process, product or equipment in the field. The award will be presented at a ceremony during the Annual Meeting of the Institute in San Francisco in December. Marshall will deliver the main address.

E. M. (Matt) Jones has been promoted to manager of Monsanto's Addyston, Ohio, plant, moving up from the post of manufacturing superintendent in charge of Texas City's styrene and vinyl chloride units. Jones joined Monsanto in 1946 at the William G. Krummrich Plant in Illinois, and transferred to Texas City in 1947. He has for some time been chairman of the National Membership Committee of A.I.Ch.E.

John B. Mellecker has joined the staff of Chemical Processing as Editor East. Mellecker, long in the chemical editorial field, will establish the first eastern editorial office for the publication. He was formerly editor of *CEP*.

Harry Marty becomes manager of Dewey & Almy's new Owensboro, Kentucky, plant. Marty has been manager, Development Department, Organic Chemicals Division. He joined the company in 1950 as process development engineer.

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people

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James B. Weaver II received the AACE "Award of Merit" for 1959. The citation was for his outstanding work in preparing an annual bibliography of cost engineering articles, books and other publications. Weaver's first cost bibliography appeared in 1954, and covered the field of cost publications in the chemical industry from 1923. He has also written articles on cost, profitability, and cost engineering for publications. Weaver is manager, economic evaluation, Atlas Powder, Wilmington, Delaware.

Other members of the Institute honored at the AACE annual meeting in June were: **O. T. Zimmerman**, chairman of the Department of Chemical Engineering, University of New Hampshire, and **Irvin Lavine**, Industrial Research Service. They were awarded Life Memberships in the organization.

Chalmer G. Kirkbride (r) is congratulated by R. Kistler, president of Beaver College, at the commencement exercises of the College, after receiving an honorary Doctor of Science degree for outstanding achievement in the field of science and research. Kirkbride, executive director research and engineering, Sun Oil, and president, Avi-Sun, delivered the commencement address to over 100 students.

Kenneth Alan Smith has been awarded an American Viscose Corp. Fellowship at MIT. The grant, one of six fellowships and sixteen scholarships established by the company, will be used to further his study of chemical engineering during the academic year 1959-60. Smith received both his SB and SM degrees from MIT.

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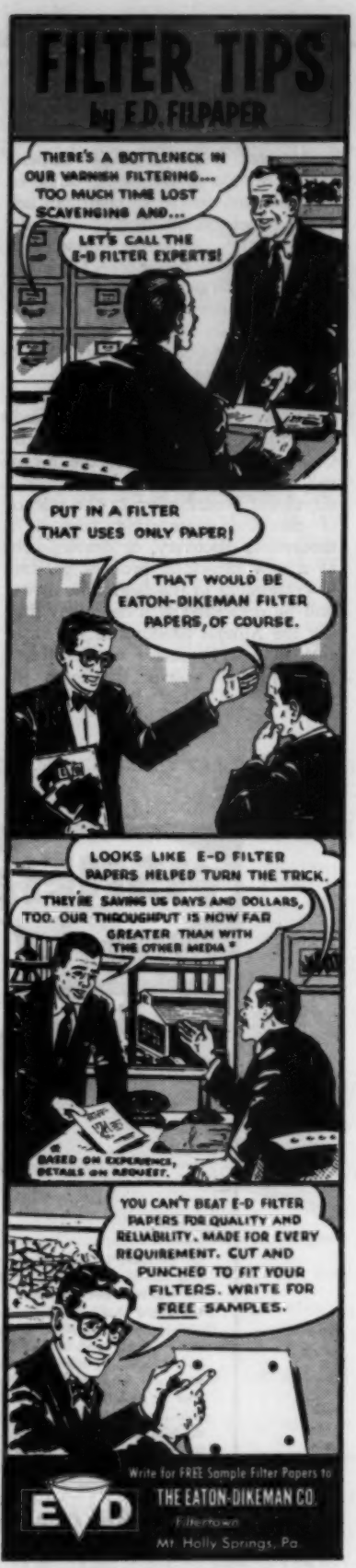
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CHEMICAL ENGINEER — 39, Ph.D., P.E. Seventeen years' in pilot plants, process design, process improvement, cost estimation, economic evaluation, project engineer in organic field, college instructor, seeking responsible assignment with opportunity. Minimum salary of $12,000. Box 11-8.

(Continued on page 148)

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(continued from page 147)

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people

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Mack Atcheson promoted to assistant operating manager, El Paso Natural Gas products. **Virgil A. (Nick) Johnson** succeeds him as chief engineer of the Texas firm.

T. Q. Eliot named manager, Process Development Department, Texas Butadiene and Chemical, Houston.

people in marketing

George R. Brockway has been appointed president of The Vac-U-Lift Company (Siegeler). He come to Vac-U-Lift from Rapids-Standard, where he was vice president. The Salem, Illinois, manufacturing firm also appointed **David Van Sluyters** to the management staff as advertising and sales promotion director. Van Sluyters has an extensive material handling background.

James D. Hembree appointed to a new post in the Chlor-Alkali Sales Department, Dow Chemical. He is product manager, Solvents Section. Hembree, who has been with the company since 1952, will work out of the Midland, Michigan, office.

Addition to the Sales-Service Department at Lawter Chemical is **James F. Hall, Jr.** Hall will divide his time between Chicago and Washington, acting as contact with governmental agencies.

Earl Carr will head new chemical division set up by Denver Equipment Co. The sewage division of Deco has been incorporated into the new section.

Edwin W. Vereeke has been elected president of Heil Process Equipment. Vereeke, who joined the company in 1946 as an estimator, succeeds Carl E. Heil. The founder and former president was elected chairman of the Board of Directors.

E. A. Stafford has become plant manager of Buckeye Cellulose's Memphis, Tenn., pulp manufacturing unit. Stafford, who has been with Buckeye for seven years, was in charge of process development work in both wood and linter cellulose pulps in the company Technical Division. He is president of the Memphis Section of A.I.Ch.E.

SITUATIONS WANTED

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CHEMICAL ENGINEER—Ph. D. Twenty years' experience petroleum, petrochemicals, organic chemicals, detergents, glyceride oils, polymers; all phases of technical activity, both supervisory and independent work, teaching. Desire senior position. Box 24-S.

CHEMICAL ENGINEER—M. Ch. E., P. E., Publications, Age 37, with thirteen years' diversified experience in technical management. Desire position in R & D or Engineering with additional emphasis on technical trouble shooting and liaison with other company functions. Box 25-S.

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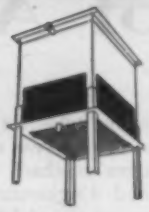

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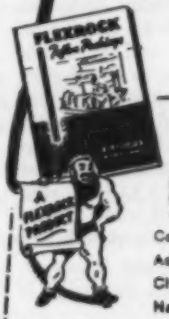

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News and Notes of A.I.Ch.E.

Over the top—Just before the end of June of this year enough checks and pledges reached the offices of the United Engineering Center in the name of the A.I.Ch.E. to push the total contributed by the members to over $300,000. This was the signal for a long-drawn breath of relief in the offices of the A.I.Ch.E., because the quota assigned by the United Engineering Trustees to the chemical engineers as their contribution to the new United Engineering Center soon to be built in New York was the goal just passed—$300,000.

This achievement should be the source of a great deal of pride to all chemical engineers whether members of the A.I.Ch.E. or not, whether contributors to the fund or not, for it means that we are the first society to reach the goal assigned for its members.

Great thanks is due to the captains and solicitors in the fund drive; almost without exception the Local Sections turned in wonderful results, and as of the end of June twenty-six sections had achieved one hundred per cent or more of the amounts that they were asked to raise. Some sections achieved really amazing performances. The Southern Nevada Section collected 291% of its quota—almost three times what it was asked to raise—followed by Detroit with 241%, Southwest Louisiana with 232%, and St. Louis with 208%. In addition to the thanks that go to the captains of the drive, such leaders of special drives as Sid Kirkpatrick and Walt Whitman, who headed the Special Gifts Drive, and Don Katz, president of A.I.Ch.E., who was Chairman of the Member Giving Campaign, deserve a special nod.

Meeting this first quota, however, does not mean that the campaign is over. Still uncollected from sections that have not reached their quota and are still soliciting is some $69,000, and plans now call for an attempt on the part of the chemical engineers to collect a substantial part of that amount. There is a perfectly good reason for this. Building costs have risen over what was anticipated, and though society quotas will not be raised, each society is going to try to raise more than the originally assigned amount. A.I.Ch.E. and the other societies must in any event try to raise more than their quota because inability to meet pledges, deaths, transfers out of the profession, etc., will take a toll of the amount pledged. The Executive Committee, therefore, at a recent meeting, considering that there was still a reasonably large quota uncollected and that more money will be needed, will in the fall approach the sections with large uncollected amounts about the possibility of reorganizing to help their particular geographical area make a better showing. A little later, when the performance is finally evaluated, A.I.Ch.E. can feel that as the newest Founder Member of United Engineering Trustees, we have shown that we can more than pull our weight.

John Fritz Medal—At the same meeting of the Executive Committee mentioned above, an invitation from the United Engineering Trustees to participate as a fifth administrator of the John Fritz Medal was received. The John Fritz Medal was established in 1902 in honor of a pioneer in the iron and steel industry and is awarded annually for "scientific or industrial achievement in any field of pure or applied science." In the past it has gone to such men as Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Edison and in more recent years to Kettering and Von Kármán, among others, but never in its long history has a chemical engineer or a chemist received it.

Since representatives on the Fritz Board are usually presidents or past presidents of the engineering societies, the representatives of the A.I.Ch.E. are D. L. Katz, G. E. Holbrook, J. H. Rushton, and W. G. Whitman, and alternates to them are C. F. Prutton, R. P. Genereaux, D. M. Calkins, and B. F. Dodge.

New student charter counselors—Newly appointed Student Chapter Counselors are Colorado School of Mines, Lyman W. Morgan; University of Nebraska, Richard E. Gilbert; University of North Dakota, W. R. Kube; University of Texas, W. A. Cunningham.

New Local Section—A Local Section charter has been given to the chemical engineers in and around Longview, Texas, whose group will be known as the East Texas Section.

Directory supplement—Late in July the Institute hopes that it will have in the mail a supplement to the 1959 Directory, giving the latest and most up-to-date information on committees, Local Section officers, representatives to other groups. Owing to the fact that forms had to close early for the '59 Directory, some of the committees were incomplete at press time; through this Supplement however we shall be able to inform Institute members of the latest information about our committees.

Incidentally, any member of the A.I.Ch.E. who wishes a Directory merely has to drop a note to this office asking for one.

National Research Council—Also appointed by Council recently, to a three-year term as our representative to the Division of Engineering and Industrial Research of the National Research Council was W. R. Collings of Dow-Corning, a director of A.I.Ch.E.

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